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NEW YORK, NOVEMBER, 1891.

IT is understood that reports have been in circulation that the RAILROAD AND ENGINEERING JOURNAL has been sold. These reports are untrue, and the JOURNAL will continue to be published under the same control and management and by the same proprietor as heretofore. The only changes to be made are in the direction of improvements which, it is hoped, will increase its interest and value to readers.

ON another page will be found the first part of an article in which the writer has endeavored to compare the English and American locomotives on the basis to which any such comparison must be brought at last—the amount of work they are doing and the cost at which that work is done. The manner in which this comparison is made is explained in the article itself. It will be followed up by a careful analysis of the performance of locomotives here and on English roads, showing the differences in the cost of locomotive service here and there. A large amount of data has been collected bearing upon these points, which it is thought will be of interest to both American and foreign engineers.

The series of papers begun by Drs. Dudley and Pease will be continued during the coming year, and will include some subjects of importance which have not yet been touched. Other papers have been arranged for, and it is believed that the JOURNAL will be able to hold the attention of its readers and to make itself acceptable to a continually increasing number.

THE success attained in transmitting power by electricity over considerable distances has attracted much attention in Europe, and in Switzerland particularly the water-powers on the small mountain streams are being eagerly taken up. These are numerous in that country, but have been neglected hitherto, because they are generally in places where it would be difficult or impossible to establish a factory. Now that it has been found that space for a water-wheel and dynamo is enough at the fall itself, the demand is so great that there is a call for some Government regulation of the subject.

AN account is given on another page of the timber tests which have been undertaken by the Forestry Division of the Department of Agriculture. The importance of this work will be appreciated by engineers generally, and it is to be hoped that they will do all in their power to help Mr. Fernow, the Chief of the Division, in his efforts to make the tests complete. A little work only from each man who is in a position to do it will make in the aggregate a very great help to the Department; and a word spoken in favor of the tests may also be of service.

THE Road Congress which is to meet in Pittsburgh on November 23 has for its object the discussion of plans for the improvement of highway roads throughout the country. It is stated that delegations from 25 States will be present, and the Congress will include many men of ability and standing. Discussion and the education of public opinion on this subject are needed, and there is much which can be done by such an assembly as that which is expected in Pittsburgh. The importance of the matter is not fully appreciated by those most directly interested, and until it is reform is not to be expected.

THE great plant which the Bethlehem Iron Company has built up for forging armor-plates and guns has now fairly begun work, and for the first time it is possible for the Government to obtain the heaviest forgings of this class at home. The establishment of such a plant in this country, where the demand for war material is intermittent, has required considerable faith in the future. That it could be done here no one doubted; the only question has been whether the demand would warrant manufacturers in putting up the costly plant required to do it.

THE needs of the Department of Transportation at the Columbian Exhibition were well presented to the American Railroad Association and the Superintendents' Society by Mr. Smith, its chief, and if the members of those bodies were thereby persuaded to take an active interest, much has been secured. The plans prepared for the buildings for the Transportation exhibit are excellent, and we regret that lack of space has prevented us from publishing them in the present number.

There is much work still to be done to bring out a proper showing. No country has done more toward improving methods of transportation than this, and the exhibition ought to be a very prominent feature of the World's Fair in 1893. Doubtless the manufacturers will be well represented, but the general and historical features ought to be shown also, and that will take time and care, if it is done properly.

THE building of underground railroads in New York, as proposed by the Rapid Transit Commission, presents so many difficult questions in engineering, that differences of opinion among experts may be expected. The reports of the consulting engineers of the Commission show that such differences exist, and that it will not be easy to reconcile all the conflicting views.

The final report of the Rapid Transit Commission, a summary of which will be found elsewhere, approves of

what has been known as the Worthen plan of four tracks on a level and generally near the surface. The Commissioners evidently hope that electricity may be used for the motors, but the use of steam may be admitted.

The report does not refer to the system which was used very successfully in London, the deep tunnel and the Greathead system of working. The plans for New York provide for tunnels much nearer the surface than that of the City & South London line, and a deeper tunnel is hardly considered practicable here. The building of the tunnel, should it be actually undertaken, will present many interesting points.

ENGLISH AND AMERICAN LOCOMOTIVES.

I.

In *The* (London) *Engineer* of November 7, of last year, a table was published showing the traffic receipts, and also "locomotive, carriage, and wagon department expenditures" of the principal railroads in England, Scotland, and Ireland for the half of the year 1888. Since then our cotemporary has repeatedly asked for similar data concerning the performance of American locomotives. We have heretofore commented on the difficulty of furnishing such statistics for the reason that the locomotive reports published here by our railroad companies differ very widely from each other in their form, arrangement, and the information which they contain. This is not collated by any government or other authority, and therefore the only way to obtain general statistics concerning the performance of American locomotives is to apply to the superintendents of motive power of the different roads in this country for their reports. This we have done, but it has taken much time, which, with the labor of tabulating the data they contained, in order to make the various items comparable, and the subsequent explanatory correspondence, must account for the lateness of our reply to *The Engineer's* criticisms, or rather, animadversion of American locomotives. Nearly all the superintendents of motive power to whom we have applied have responded to our requests for reports and information very cheerfully and liberally, and to these our thanks are due, and are here expressed publicly.

Table I contains all the data relating to the performance of British locomotives which *The Engineer* gave last November. Table II gives similar but fuller information concerning the working of American locomotives. It should be observed that the first table, giving the performance of British locomotives, covers a period of a half year only, whereas the second, relating to American locomotives, covers a whole year.

In *The Engineer* of July 24, its editor says, rather triumphantly, that "every attempt that has been made by writers on the subject to prove the superiority of the American locomotive has been so far a dead failure." Our cotemporary does not refer to the fact that it has been clearly shown that the maximum coal consumption per square of grate per hour of American locomotives is more than twice as great as that of English locomotives, and that the quantity of water evaporated is nearly in the same proportion. On the authority of our cotemporary we have it that "about 75 lbs. (of coal) per square foot of grate per hour may be regarded as a *maximum consumption.*" We have shown consumptions of 121.6, 132.2, 148.1, and 193.7 lbs. of coal per square foot per hour, and Mr. Dean, in experiments made on the Union Pacific Railroad, burned over 200 lbs.* We have shown an evaporation of water equal to 739.12 lbs. per square foot of grate per hour with a poor quality of coal. Mr. Dean, on the Old Colony, evaporated over 1,000 lbs. with good coal. It will be shown farther on that this greater capacity for burning coal and generating steam has an important bearing on the cost of transportation.

Our esteemed disputant remarks in a recent article, that "what we have written on the subject has no doubt elicited a great deal of information which American engineers did not before possess." It seems as though some information, elicited by what has been written on this side the Atlantic, must be new, if not to British engineers, at least to our cotemporary. We submit that some advantage may be claimed for our locomotives, if they are capable of burning more than twice as much coal and evaporating nearly the same proportion of water, and can consequently pull greater loads than locomotives which do not generate a corresponding amount of steam.

But a study of what we may call our international tables will reveal some other information which perhaps British engineers "did not before possess." In these tables it will be seen that the number of locomotives owned by the different companies is given in the second column, the total mileage in the third, and the average mileage in the fourth. At the foot of this column the aggregate average mileage is given. This is obtained by dividing the total engine mileage by the whole number of engines. In Table II the total number of all locomotives capable of service, and owned by different American railroad companies, is given. Whether the table of English engines gives *all* the engines owned or only those in service, we are unable to say. It will be seen, though, that the average mileage of British engines for a half year was 12,305, equivalent to 24,610 miles per year. The average of nearly 15,000 American locomotives, as shown by our table, was 35,650 miles. When facts of great importance are announced simply by two sets of figures, they often do not convey an adequate idea of their significance. We, therefore, represent graphically the relative average mileage of locomotives here and on the other side the water, by the following diagram, in which the lengths of the dark lines represent the proportionate average service which British and American locomotives perform annually.

Average annual mileage of English Locomotives.

24,610 miles.

Average annual mileage of American locomotives.

35,650 miles.

To show the *maximum* mileage, we have obtained from a number of different roads the greatest distance run by each of three engines, which ran farthest during the last year. The results are given in Table III.

We have seen the report of the remarkable mileage of the "Charles Dickens" on the London & North Western, which ran a million miles in less than ten years, or an annual mileage during that time of over 104,000 miles, which exceeds anything in our table. The figures which we give are, however, taken from ordinary, every-day practice of 33 different roads. Can *The Engineer* give its

* The coal used on the Union Pacific is of a very free-burning quality.

TABLE I. SHOWING THE TRAFFIC RECEIPTS, ALSO LOCOMOTIVE EXPENDITURES OF THE UNDERNOTED RAILWAYS OF ENGLAND, IRELAND AND SCOTLAND FOR THE HALF YEAR ENDING 30TH JUNE AND 31ST OF JULY, 1888.

1 NAME OF ROAD.	2 Number of Locomotives.	3 Total Mileage of Locomotives for Half Year.	4 Average Mileage for Half Year.	5 Traffic Receipts per Train, Mile. Pass.	6 Goods.	7 Coal Consumed per Engine, Mile.	8 Cost of Fuel per Engine, Mile.	9 Cost of Repairs per Engine, Mile.	10 Cost of Working per Mile Run.	11 Total Cost of Locomotive Service per Engine, Mile.
ENGLISH.				£	£	lbs.	cts.	cts.	cts.	cts.
London and North Western	2,323	27,035,313	11,658	4/ 0.49	6/ 7.52	40.04	2.51	5.32	10.92	18.75
Great Western	1,600	19,107,351	11,943	4/ 3.86	5/ 3.76	32.51	2.36	6.02	9.18	17.56
Midland	1,807	21,270,252	11,771	3/ 2.37	5/ 2.23	39.51	2.56	4.74	10.30	17.60
North Eastern	1,506	17,102,558	11,356	3/ 2.34	6/ 2.00	36.52	2.54	8.98	11.22	22.74
Lancashire and Yorkshire	948	11,611,396	12,248	3/ 5.50	7/10.21	39.62	2.33	6.10	11.38	19.81
Great Northern	798	10,333,286	12,949	3/ 0.13	4/ 6.32	40.65	3.11	4.72	10.48	18.31
Great Eastern	733	9,530,014	13,001	3/ 5.09	5/ 0.52	35.21	3.63	4.32	10.40	18.35
London and South Western	548	8,023,716	14,642	4/ 4.52	5/ 7.41	26.90	3.48	4.08	12.10	19.66
London, Brighton and South Coast	410	4,839,860	11,805	4/ 2.91	7/ 4.28	29.42	4.90	4.28	12.54	21.72
South Eastern	338	4,618,454	13.664	4/11.84	6/10.42	32.75	3.84	3.62	12.14	19.60
London, Chatham and Dover	180	2,389,980	13,278	4/ 9.42	8/10.53	30.95	4.76	5.22	12.74	22.72
North Staffordshire	131	1,375,348	10,499	3/ 0.17	7/ 7.78	38.66	2.22	6.58	7.44	16.24
Furness	119	892,938	7,504	2/10.81	11/ 2.01	46.22	4.23	4.84	15.18	24.25
Taff Vale (Wales)	169	2,238,082	13,243	5/ 5.97	7/11.59	38.49	2.76	11.74	10.94	35.44
Metropolitan	67	1,090,650	16,278	6/ 0.14	——	37.20	6 07	4.76	13.90	24.73
Metropolitan District	54	819,148	15,169	4/11.39	——	30.50	5.13	3.72	11.66	20.51
North London	80	1,236,771	15,460	3/ 4.69	11/ 5.52	30.73	5.28	5.54	13.90	24.72
Cambrian	51	667,298	13.084	2/11.38	4/ 1.96	35.87	2.92	3.78	9.04	15.74
Maryport and Carlisle	26	257,631	9,909	2/10.00	6/ 2.60	45.00	4.18	5.82	11.34	21.34
Total	11,888	144,440,046	12,150	3/10.24	5/11.07	36.61	2.90	5.54	10.92	19.36
IRISH.										
Great Southern and Western	176	1,868,913	10,619	3/ 8.34	5/10.93	27.24	3.72	6.18	10.06	19 96
Midland Great Western	104	1,124,608	10,814	3/ 3.25	6/ 7.68	29.03	3.72	5.04	8.96	17.72
Dublin, Wicklow and Wexford	51	616,892	12,096	3/10.48	5/ 0.13	27.11	3.60	3.60	8.56	15.76
Belfast and Northern Counties	52	597,631	11,493	2/ 5.99	5/ 6.13	27.01	3.49	3.44	8.80	15.73
Great Northern	137	1,791,033	13,073	3/ 3.72	6/ 4.84	26.76	3.61	3.88	9.08	16.57
Total	520	5,999,077	11,537	3/ 4.81	6. 1.25	27.39	3.65	4.74	9.26	17.65
SCOTTISH.										
Caledonian	690	8,634,143	12,513	3/ 5.02	5/ 9.79	49.65	2.09	4.46	8.54	15.09
North British	610	9,453,125	15,497	3/ 3.09	4/ 9.32	43.04	2.09	3.06	8.64	13.79
Glasgow and South Western	291	3,428,202	11,781	3/ 8.39	5/ 4.07	48.37	2.44	4.52	8.74	15.70
Great North of Scotland	74	1,216,745	16,443	2/11.33	5/ 2.68	37.37	3.58	3.54	8.74	15.86
Total	1,665	22,732,215	13,653	3/ 4.41	5/ 3.25	46.04	2.22	3.82	8.62	14.66
Aggregate Total	14,073	173,171,338	12,305	3/ 9.30	5/10.08	37.53	2.84	5.30	10.58	18.72

readers a report similar to ours of the maximum mileage of English locomotives in ordinary service?

It seems hardly necessary to dwell upon the advantage which American locomotives possess over their Anglican cotemporaries, in their greater capacity for doing what they are made for—that is, for running and pulling trains. If we were arguing about horses, it would be apparent that an animal which would travel, on an average, 35 miles per day was a much more serviceable and more valuable beast than one which would travel only 24 miles, even though the one which could travel farthest eat more oats than the other. The same thing is true of locomotives. Railroad companies buy, build, and own them for the service they can perform. That is what gives them value. Our adversary, apparently, entertains—vaguely, perhaps—the idea that the "chief end" of a locomotive is to evaporate the largest quantity of water per pound of coal. A maximum evaporation of water is of some importance, but to a railroad company, crowded with traffic, and an insufficient equipment, the *service capacity* of their locomotives is paramount to everything else. Its influence on the interest account is a matter of simple calculation. Supposing a road, say in some new country, is equipped with 250 American locomotives. These, at $8,000 each, would cost $2,000,000. To do the same work, 375 English locomotives would be needed at a cost—assuming the same price—of $3,000,000. That means, of course, $1,000,000 more capital and an annual interest charge of $50,000, without any allowance for deterioration. It also means more engine-house capacity, more men to take care of engines, more yard and shop room, and a very great addition of expense in the locomotive department.

The last number of "Poor's Railroad Manual" gives the total number of locomotives owned by the railroads of the United States at 32,241. If the annual mileage of American locomotives did not exceed that of their English cotemporaries, 46,704 locomotives would be required to do the work which the 32,241 are now doing. That is, 14,463 *more* than are now owned would be required to do the work of our railroads. At $8,000 apiece, this additional equipment would cost $115,704,000.

The remark of *The Engineer* that "every attempt that has been made by writers on the subject to prove the superiority of the American locomotive has been so far a dead failure," has already been quoted. It says, "The facts are too strong." Now we submit to our esteemed

TABLE II. SHOWING THE LOCOMOTIVE EXPENDITURES OF THE UNDERNOTED RAILWAYS IN THE UNITED STATES AND CANADA FOR THE YEAR 1890.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
NAME OF ROAD.	Number of Locomotives owned by Company.	Total Mileage of Locomotives for Year.	Average Annual Mileage of Locomotives.	Average Number of Cars per Train.		Coal Consumed per Engine, Mile.			Cost of Fuel per Engine, Mile.	Cost of Repairs per Engine, Mile.	Cost of Oil Waste and Miscellaneous Supplies per Mile Run.	Wages of Engineer, Fireman, and Cost of Cleaning per Engine, Mile.	Total Cost of Locomotive Service per Engine, Mile.
				Pass.	Frg't.	Pass.	Frg't.	Pass. and Fr'g't.					
								lbs.	cts.	cts.	cts.	cts.	cts.
Boston and Albany*	240	5,979,896	24,916	...	...	...	...	69.00	...	4.40	0.56	...	...
Boston and Maine†	448	11,934,272	26,661	...	...	...	...	47.50	10.14	3.11	0.39	6.74	20.38
Burlington, Cedar Rapids and Northern	104	3,424,314	32,926	3.65	15.40	...	...	75.00	5.73	3.87	0.41	6.91	16.92
Canadian Pacific	532	17,474,438	32,847	...	...	...	...	62.00	11.07	3.83	0.39	6.50	21.79
Chesapeake and Ohio	238	8,797,269	36,963	4.52	18.90	63.65	127.39	...	4.02	4.54	0.29	6.59	15.44
Chicago and Alton	207	7,044,699	34,032	5.20	20.32	72.3	96.1	80.00	4.31	3.62	0.60	8.00	16.53
Chicago, Burlington and Quincy	473	19,259,373	40,717	4.99	18.22	...	...	82.71	5.72	4.70	0.35	7.04	17.81
Chicago, Milwaukee and St. Paul	757	27,636,934	36,504	...	...	...	...	70.90	7.21	3.82	0.26	6.86	18.15
Chicago, Rock Island and Pacific	534	19,242,100	36,034	...	...	...	...	60.00	5.77	3.07	0.32	6.57	15.73
Chicago, St. Paul, Minneapolis and Omaha	230	7,031,562	30,572	...	...	...	...	70.00	10.17	3.94	0.38	7.14	21.63
Chicago and North Western	806	30,495,091	37,833	...	...	...	...	78.70	7.14	3.67	0.35	7.00	18.16
Cincinnati Southern	226	7,684,118	34,000	4.30	22.80	55.00	98.00	71.00	5.80	4.40	0.30	7.40	17.90
Cleveland, Cincinnati, Chicago and St. Louis	438	15,723,929	35,899	4.50	21.40	63.21	106.72	80.29	5.69	3.19	0.32	6.78	15.98
Delaware, Lackawanna and Western	244	8,147,097	33,389	...	...	...	...	78.00	5.99	3.26	0.46	5.81	15.52
Fitchburg	221	6,304,182	28,525	...	...	...	...	71.90	10.89	4.61	0.66	9.27	25.43
Illinois Central	535	18,605,304	34,776	4.49	15.36	74.9	108.4	90.60	4.59	3.34	0.28	6.46	14.67
Kansas City, Ft. Scott and Memphis	149	4,770,148	32,014	...	...	...	...	60.30	5.21	4.12	0.24	7.14	16.71
Lake Shore and Michigan Southern	549	19,509,322	35,536	...	...	...	...	62.80	4.36	4.84	0.16	6.84	16.20
Louisville and Nashville	462	17,990,574	38,940	5.11	13.11	60.5	93.3	...	7.16	5.17	0.27	7.98	20.58
Michigan Central	420	16,200,768	38,573	5.50	32.00	72.71	128.00	...	6.93	3.36	0.26	5.33	15.88
Milwaukee, Lake Shore and Western	100 3/12	3,903,620	38,939	...	...	...	...	75.70	10.64	2.56	0.31	6.64	20.15
Missouri, Kansas and Texas	212	8,559,852	40,376	4.80	16.91	...	...	83.10	8.32	4.66	0.42	7.93	21.33
Missouri Pacific	309½	10,825,213	35,033	4.56	18.32	...	...	87.00	6.99	4.77	0.45	7.73	19.94
Mobile and Ohio	98	3,137,928	32,019	...	23.4	...	...	63.40	3.86	3.97	0.35	6.90	15.08
New York Central and Hudson River	800	27,456,016	34,320	5.00	33.90	...	...	...	...	2.61	0.33	6.25	...
New York Elevated	250	8,541,037	34,164	4.56	...	47.85	...	47.85	8.90	1.70	0.30	8.62	19.52
New York, Lake Erie and Western	556	19,672,746	35,383	4.90	21.80	85.00	122.4	...	6.83	5.32	0.41	8.18	20.74
New York, New Haven and Hartford	190	7,966,161	41,927	...	...	...	...	60.00	8.48	3.61	0.64	7.37	20.10
New York, Pennsylvania and Ohio	254	8,153,297	32,099	5.10	19.10	70.00	117.9	...	5.68	4.17	0.31	7.60	17.76
Ohio and Mississippi	116	4,605,967	37,982	...	...	...	...	73.60	3.54	3.59	0.20	6.78	14.11
Old Colony†	227	6,558,675	28,893	...	...	...	...	55.80	11.18	3.49	0.58	7.54	22.79
Pennsylvania (United R.Rs. of New Jersey)	385	12,076,374	31,341	4.94	23.67	82.4	108.8	78.40	11.59	6.21	0.72	6.45	24.97
Pennsylvania (Philadelphia to Pittsburg)	991	31,648,320	31,936	4.95	24.37	67.5	136.00	100.60	5.75	5.28	0.50	6.22	17.75
Pennsylvania Lines West of Pittsburg (N. Western System)	441	16,188,889	36,710	5.33	23.87	58.87	100.36	...	5.00	4.96	0.32	6.74	17.02
Philadelphia and Erie	186	5,268,503	28,325	3.84	32.66	60.00	153.8	124.30	7.41	6.29	0.38	6.16	20.24
Philadelphia, Wilmington and Baltimore‡	193½	7,505,439	38,788	4.40	17.40	...	...	62.00	8.50	6.05	0.58	5.62	20.75
St. Louis and San Francisco	169	5,570,373	32,690	...	...	...	...	80.10	5.89	4.85	0.34	7.59	18.67
Union Pacific	909	34,846,343	38,334	5.16	16.26	...	...	94.50	10.26	6.60	0.45	9.14	26.45
Wabash	403	15,099,843	37,468	4.79	22.13	...	...	74.24	4.53	3.17	0.35	7.11	15.16
Western New York and Pennsylvania	121	3,959,957	32,727	3.30	20.40	...	...	78.70	5.06	3.76	0.37	6.55	15.74
Wisconsin Central	134	5,089,187	3[illegible]979	...	...	...	...	75.80	9.19	3.46	0.25	6.92	19.82
Totals	14,863 3/12	519,889,130	...	...	...	...	...	...	...	...	...	...	...
Averages	...	...	35,650§	...	...	...	...	74.37¶	...	4.25**	0.39††	7.06**	18.87‡‡

* This Company has a large number of old locomotives too light for its service which make little mileage.

† A considerable proportion of the engines of this Company are not employed in winter.

‡ The engines and mileage on the Baltimore and Potomac road are included here.

§ This average is obtained by dividing the total number of miles run by the total number of engines.

¶ This is the result of multiplying the number of miles run on each road by the quantity of coal burned and adding the products thus obtained and dividing by the sum of the mileages on all the roads.

** This average is obtained in the same way as that at the foot of column 9, but using the cost of repairs per mile run on each road as a multiplier.

†† This is the average of the averages of each road.

‡‡ This is obtained by multiplying the total cost of locomotive service per mile run on each road by the total number of miles run and adding the products together and dividing by the number of miles run on all the roads.

adversary and to our readers the question, whether a $115,000,000 fact has not "considerable" strength.

COAL CONSUMPTION.

The strong point which *The Engineer* has dwelt upon during the discussion of the relative merits of our locomotives and theirs has been the greater economy of their locomotives in the consumption of coal. From our tables it will be seen that the average consumption on British roads, for the half year covered by Table I, is 37.53 lbs. per engine mile, whereas on the American roads, of which the consumption is reported in column 9 of Table II, the average is 74.37, or almost exactly twice as much as that

TABLE III.—GREATEST ANNUAL MILEAGE OF LOCOMOTIVES ON DIFFERENT ROADS.

	Miles.	Miles.	Miles.
Western New York & Pa	51,269	50,572	50,157
Chicago & Alton	51,433	50,026	46,968
Kansas City, Fort Scott & Gulf	55,538	50,436	45,351
Old Colony	55,832	55,098	54,238
Canadian Pacific	57,156	56,466	56,399
Mobile & Ohio	59,000	48,446	44,289
Wisconsin Central	60,784	48,628	47,399
Chicago, Milwaukee & St. Paul	60,928	60,523	59,888
Missouri, Kansas & Texas	61,729	58,763	54,190
Wabash	61,785	59,625	57,823
Delaware, Lackawanna & Western	63,581	60,500	60,374
Milwaukee, Lake Shore & Western	65,750	63,660	61,970
Illinois Central	66,428	64,837	57,081
Ohio and Mississippi	16,498	65,200	64,349
Manhattan Railway	67,785	57,729	56,725
Boston & Albany	70,217	67,965	66,781
Cincinnati, New Orleans & Texas Pacific	70,356	67,850	66,857
Chesapeake & Ohio	71,084	50,053	49,756
Burlington, Cedar Rapids & Northern	71,630	51,980	51,360
Pennsylvania (United Railroads of N. Jersey)	74,268	.....	......
Michigan Central	77,913	76,272	75,196
Philadelphia & Erie	79,868	......	.....
Union Pacific	80,198	79,650	73,763
Fitchburg	81,262	69,177	52,196
Atchison, Topeka & Santa Fe	83,076	81,243	73,919
Lake Shore & Michigan Southern	86,155	83,038	79,251
Pittsburgh, Fort Wayne & Chicago	86,240	84,642	81,854
Pennsylvania (Philadelphia to Pittsburgh)	86,635	......	......
Missouri Pacific	88,240	63,127	57,654
Philadelphia, Wilmington & Baltimore	91,680	88,044	84,576
Louisville & Nashville	*96,541	88,904	87,909
Chicago, Burlington & Quincy	97,257	95,425	91,414
New York, Central & Hudson River	97,384	95,096	93,662
Chicago & North Western	99,207	87,299	69,633

* This engine was in service only nine months, and made this mileage in that time

of the British engines. If this consumption was of coal of the same quality, and in doing the same amount of work, and if the relative merits of locomotives depended entirely on the fuel consumption, it would, of course, be a bad showing for our engines.

With reference to the quality of American coal, we have taken occasion before to say that it varies within very wide limits. Through the courtesy of Mr. Leeds, Superintendent of Machinery of the Louisville & Nashville Railroad, we are able to give the relative consumption of 16 different kinds of coal, as determined by careful, practical tests in running passenger trains on that road. The comparison is made with good Pittsburgh coal, which was rated at 100. The consumption was as follows :

TABLE IV.—VALUE of DIFFERENT KINDS OF COAL.

Coal No. 1.	Pittsburgh (good), Consumption	100.
" " 2.	" " "	109.79
" " 3.	" " "	112.84
" " 4.	" " "	117.05
" " 5.	" " "	124.33
" " 6.	" " "	125.03
" " 7.	" " "	128.84
" " 8.	" " "	129.75
" " 9.	" " "	131.21
" " 10.	Pittsburgh (poor) "	134.83
" " 11.	" " "	138.29
" " 12.	" " "	138.57
" " 13.	" " "	139 49
" " 14.	" " "	149.04
" " 15.	" " "	162.61
" " 16.	" " "	181.05

From this table it will be seen how widely the coal which is used in this country differs in quality and value. It is by no means certain that the poorest coal tested by Mr. Leeds is the worst that is used, as he only experimented with fuel available for his own road. Evidently it would be idle to expect that an engine using the No. 16 coal would burn as little per mile as another would which used "good Pittsburgh."

We have no direct testimony bearing upon the relative value of English and American coals, but all the information received from persons who have had experience, both here and in England, is to the effect that the coal used there is much better than the average here, especially better than that used in our Western States. In 1844 Professor Johnson made a series of elaborate tests on coals for the Secretary of the U. S. Navy. These were probably the most complete experiments ever made on American coals. He also tested a few samples of English and Scotch coals. Without going into minute fractions his conclusions may be summarized by the following figures :

Water evaporated per lb. of Scotch coal	6⅝	lbs.
" " " " " Liverpool (England)	7	"
" " " " " Pittsburgh (Pa.)	7	"
" " " " " Newcastle (England)	7¾	"
" " " " " Cumberland (Md. and Pa.)	8½	"

These figures give some idea of the relative value of these different coals. It should be added that Pittsburgh and Cumberland coals are among the best in this country for steam generating purposes. All Western coals are of poorer qualities, descending almost to incombustibility.

The impossibility of making any comparison which will be conclusive of the relative economy of locomotives using fuel varying so widely in quality as that which is used on English engines and in this country must be obvious.

From Table I it will be seen that the consumption on the Scottish roads averages 46.04 lbs. per mile, or nearly 30 per cent. more than on English lines, with the probability, too, that trains in Scotland are lighter than in England. This is due to a great extent, probably, to the poor quality of the coal used there.

In our next article we will make some comparison of the loads hauled on British and American railroads, and of the relative cost of repairs in the two countries, and also of the cost of locomotive service per ton of train hauled per mile.

(TO BE CONTINUED.)

AFRICAN TRANSCONTINENTAL RAILROADS.

THE French engineer is nothing if not comprehensive and general in his plans : and accordingly M. Beau de Rochas, in advocating the building of the Trans-Saharan Railroad, has outlined a system of great African lines.

The Trans-Saharan line, according to M. de Rochas, should be considered not only as a connection between France and its commercial colonies and outposts in the Western Soudan and Senegambia, but as part of a transcontinental route which will shorten by nearly one-half the time of transit between French ports and the greater part of South America. The road to be built by France should not be merely the Trans-Saharan ; it should be the Western Trans-African, and should have its northern termini at the ports of Oran and Djidjelli in Algiers and its southern at Rio Nuñez on the Senegambian coast. Now the shortest possible line across the Atlantic between America and the Eastern Continents is one drawn from Cape San Roque or the port of Pernambuco near by, to Rio Nuñez. Even at the moderate speed of 13 or 14 knots an hour the ocean can be crossed there in 5½ days, while at 19 or 20 knots the time would be less than four days. But if we adopt the lower speed, the voyage from Pernambuco to Marseilles,

the proposed railroad being completed, could be made in nine days, as against 16 or 17 now required. For freight, allowing for transfer and the slower speed of freight trains, the gain in time would be three or four days; to this must be added the diminished risk, lower insurance and other considerations.

Whether passengers might not prefer the longer sea voyage to a ride of three or four days by rail through the heats of equatorial Africa, with risks of disease, M. de Rochas does not consider worth serious treatment, in view of the unquestioned saving in time.

Pernambuco has already rail connections with a considerable part of Brazil, and with the European line once established these will be extended until the city becomes the central point to which all the railroad systems of South America will converge. Two leading lines may be indicated; one through the Amazon Valley to Bolivia and Peru, the other leading directly to Valparaiso.

In support of this comprehensive plan a political reason is brought forward, which is perhaps best expressed in M. de Rochas' own words:

The North Americans do not conceal their purpose of extending the Monroe Doctrine to South America. But between the North Americans and the South Americans there is nothing in common but the American name. The South American is of the Latin Race. That race does not wish, it cannot, it has no right to permit itself to be absorbed by any other. Its vitality extends through the whole Latin world; and in drawing its lines of relationship closer, it will raise still higher its historical standard.

Now, the Western Trans-African Railroad, if it existed, would become—it must necessarily become—the bond of union between the Latin world on this side and on the other side of the Atlantic. The Latin world, and with it civilization, of which it is the highest and best representative, have everything to gain by this closer connection.

This is a peculiarly French view of the subject, to which some exceptions might be taken here, did space permit.

The plans of M. de Rochas will be made clearer by the accompanying sketch, on which the West African line and its American connections are shown at a glance.

But the West African line is not the only one included, although it is the first to be built. Near the southern line of the Sahara another transcontinental line will diverge and run through the Eastern Soudan and across the headwaters of the Nile to a point near Cape Guardafui, from which a comparatively short sea voyage will be required to reach the ports of India and China. This built, the tedious voyage through the Red Sea and the Suez Canal is a thing of the past.

Still another branch from a point in the Central Soudan to the East African Coast at Mozambique or the mouth of the Zambesi will furnish a short line to Australia and New Zealand. Here, then, we have a system which will revolutionize the commerce of the world and turn the entire trade of the East into new channels. Far-reaching as were the results which followed the opening of our own Pacific railroads, they will be small when compared with those attending the completion of the African Trans-continental.

The commercial center of the world will be transferred from London to Marseilles. Liverpool and New York will become seaports of merely local importance.

AFRICAN TRANSCONTINENTAL LINES.

Some difficulties will attend the building of the great African lines; but, after all, the plan of M. de Rochas appears to us no more visionary and extravagant than that of the American transcontinental did to our fathers only 40 years ago. No one will now venture to predict what projected lines will or will not be in operation in 1930.

NEW PUBLICATIONS.

BRAZIL. BULLETIN NO. 7 OF THE BUREAU OF THE AMERICAN REPUBLICS. Washington; issued by the Bureau.

The Bureau of the American Republics is one of the results of the Pan-American Congress of last year, and its object is to promote friendly feeling and to increase the knowledge of our sister republics in this country. The present monograph on Brazil is a volume of 336 pages, containing a large amount of information in relation to that country. It includes historical sketches; an account of the commercial and political geography; colonization and immigration; the mineral agricultural and forest resources; railroad and other transportation systems; financial and political systems; commercial arrangements with the United States; commercial statistics; tariffs, and a commercial directory. It is illustrated by a map of the country and a number of views of the chief cities.

The book is a valuable one to all who are interested in Brazil, or who hope to secure a share of the trade with that country. It is also interesting to the general reader. Our knowledge of South America, even among reading people, is much less full and accurate than it should be, and the publications of the Bureau are serving an excellent purpose in increasing it. The

work entrusted to it is an excellent one, and has so far been carried on with excellent judgment.

POOR'S DIRECTORY OF RAILROAD OFFICIALS AND MANUAL OF AMERICAN STREET RAILROADS: 1891. H. V. & H. W. Poor, New York; price, $2.

This is a supplement to *Poor's Manual*, and is intended to give more complete lists of railroad officers than can be inserted in the *Manual* without increasing too much the bulk of that work. It is also very serviceable for those who need only the names of officers and do not require the detailed information found in the other book.

The *Directory* contains lists of all the officers of steam railroads in the United States, with special lists of those in charge of the operating and mechanical departments, and of purchasing agents. It also gives the statements of the street railroads of the country; finally it has a directory of the railroads in Mexico, Central America, South America, the West Indies, and the Hawaiian Islands; all countries which have a close relation to this.

The work on this book has been done as carefully as that on the *Manual*, and its accuracy may be generally relied on. That it is indispensable for all who have business with railroads, it is hardly necessary to say.

BUILDERS' HARDWARE. *A Manual for Architects, Builders and House Furnishers*. By Clarence H. Blackall, Architect. Ticknor & Company, Boston; price, $5.

At first sight this might be taken, from its title, to be a trade catalogue; but an inspection of its contents will show that it is something quite different. The term "Builders' Hardware" is defined by the author as including "metal-work of every description entering into the construction and finish of a modern building, from the nails and bolts used in the rough work to the door furniture and brass lock and plate work of the finish."

This is certainly comprehensive enough; and that the book has been made to cover the subject as defined, an inspection of the table of contents and the index will show. In fact, any one not familiar with the subject will look with some wonder at the great number and variety of the articles described and mentioned.

The book has been written chiefly for architects, with a view of enabling them to make out their specifications with a better and clearer understanding of the minor details of the metal work, and of what is required in that line in a good building than most of them, who have not had practical experience as builders, can be expected to possess. In this way it may be considered a very useful book. As far as manufactures are concerned, the author seems free from bias of any kind, unless a little, and perhaps natural leaning toward Boston practice may be so considered. His judgments as to quality of work are apparently quite impartial.

The numerous illustrations have purposely been made as simple as possible; they are very good of their kind. A few more elaborate and very handsome plates are added, giving examples of artistic finishings for the higher grades of house work. The book is an admirable specimen of typographical work.

REPORT OF THE PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL CONVENTION OF THE MASTER CAR-BUILDERS' ASSOCIATION. *Held at Cape May, N. J., June 9, 10, and 11, 1891.* Chicago; published by the Association, John W. Cloud, Secretary.

This report of the Master Car-Builders' Convention follows close upon that of the Master Mechanics, a little delay being required to enable the Secretary to include in it the results of the letter-ballots ordered by the Convention. Like that of the other Association, the Convention this year had no questions of special importance before it, those which called out the most discussion being in relation to air-brake standards and repairs and inspection of freight cars fitted with air-brakes. These are comparatively new matters, and are growing in importance as the use of continuous brakes on freight trains is increasing.

The Report is carefully edited, and printed in the usual style. It has also the supplements containing the Rules of Interchange, the Standards of the Association, and Decisions of the Arbitration Committee. These alone make it valuable to officers of the car department, apart from the interest attaching to the reports and discussions.

POOR'S HANDBOOK OF INVESTMENT SECURITIES. *Second Annual Number for* 1891. H. V. & H. W. Poor, New York; price, $2.50.

Like the *Directory*, this book is intended as a supplement to *Poor's Manual*, and is especially for the use of bankers and banks, investors, and those who deal in or invest their capital in railroad securities. It contains lists of bond coupons, time and place of payment; times and places of annual meetings and payment of dividends; locations of general and transfer offices; ranges of stock and bond prices for the past year; dates of maturity of bonds; a condensed abstract of railroad returns from the *Manual*, and much other information of the kind which dealers and investors need for reference. In addition to the railroad information, there are lists of State, county, and municipal bonds, and of the securities of a number of miscellaneous corporations which are largely bought and sold.

Judging by past issues, the work is generally accurate and reliable, and the constant use of the preceding number has shown its excellence. It may also be said that it is the only work of the kind which is to be had.

A TREATISE ON WOODEN TRESTLE BRIDGES ACCORDING TO THE PRESENT PRACTICE ON AMERICAN RAILROADS. By Wolcott C. Foster. John Wiley & Sons, New York; price, $5.

This is a book on a subject concerning which a great deal has been written in a detached way—in papers and society proceedings and the like—but on which, until recently, there has been no connected treatise. That it is an important one, the author's figures show, if they are correct—and they are probably very nearly so—for he estimates that there are about 2,400 miles of wooden trestle in the United States, of which about one-quarter is only temporary, to be replaced by embankment, while probably one-third more will be replaced by iron. This would leave between 800 and 1,000 miles of what may be called permanent wooden structures, to take no account of the new ones which are constantly going up on new lines. Taking an approximation to the average cost, the 2,400 miles of trestle must have cost over $76,000,000, a sufficiently formidable sum.

Mr. Foster has aimed to give the methods of construction which are approved by general adoption, and to describe the practice on the best roads, and he has collected a large amount of information which will be of service to engineers in railroad work.

After the introduction the book has several chapters on general subjects, such as Pile-bents, Framed Bents, Pile-drivers, Floor Systems, Bracing, Iron Work, etc. There are also chapters on Erecting, on Specifications, on Bills of Material, and on Maintenance. These are followed by drawings and bills of material for eight pile trestles and 23 framed trestles, taken from actual practice on different roads, and including some bridges of extraordinary height; it may be said, in fact, that almost every sort of trestle is included.

The drawings are generally good, but in one or two cases they are too much reduced—notably in the case of those of the pile-driver car on pages 16, 17, 18, and 19, where the figures

are so small they can hardly be read without a microscope. It may also be said that though the letter-press is clear and good, the cuts are not as well printed as they ought to be in such a book.

These are minor points, however, and the book may be considered a useful addition to engineering literature.

NOTES ON MILITARY SCIENCE AND THE ART OF WAR. By Joseph M. Califf, First Lieutenant Third U. S. Artillery. *Second Edition, Revised and Enlarged.* (James J. Chapman, Washington; price, $1.)

The author of this book, who is well known to readers of the JOURNAL, prepared it originally while detailed as professor at the State University of Iowa, with the intention of supplying a text book which was much needed to supplement his lectures. It is not intended to teach the purely technical part of the military profession, but to give a general idea of the organization of an army and the manner in which it is handled, supplied and made efficient in time of war; of the weapons with which it is armed and of the manner of using them, with some lessons drawn from the great captains of the past.

Among the subjects treated are Army Organization and Administration; Lines and Orders of Battle; the Systems of Frederick and Napoleon; Modern Tactics and Strategy; Explosives, Guns, Projectiles and Torpedoes; Fortification and Sieges; Military Transport and Supply; Outposts and Reconnaissances; Management of Troops in Campaign and Military Law.

As a text-book it is excellent. The different subjects are necessarily treated in a general way, but the explanations are clear and plain, and the style is excellent. It is, in fact, somewhat more than a text-book, and is a very good work for the general reader who wishes for a general knowledge of military methods. It is sufficiently illustrated where diagrams are needed to make the subject clear.

The present edition has been largely rewritten in order to keep up with the recent rapid progress in small arms, cannon, powders and other military material. Chapters on Transport and Reconnaissance have also been added, with some account of the systems of outposts and advanced guards adopted in foreign armies.

TRADE CATALOGUES.

About Warming Railroad Cars. The Leland Car Heater & Steam Coupler Company, New York.

This is an illustrated description of the Leland Heater, which is a device for heating railroad cars by a circulation of water which has been heated by steam from the train pipes. This heater is in use on the Wagner sleeping and parlor cars, and is being put in a number of cars of the New York, New Haven & Hartford Railroad.

Industrial Railways (Synopsis). The C. W. Hunt Company, New York.

Coal Machinery (Synopsis). The C. W. Hunt Company, New York.

Manila Rope. The C. W. Hunt Company, New York.

The first of these catalogues contains a very good illustrated description of the Hunt Company's system of light railroads for factories, yards, and similar purposes. This system—which has already been described in the JOURNAL—presents many advantages, and has been adopted by a number of large factories.

The second is in part a repetition of the first, but it also describes the Hunt machinery for unloading, handling, and loading coal on a large scale. This machinery has reduced the cost of handling coal to a very low figure, and has also brought down the time required for disposing of a cargo to almost the lowest possible point.

The third catalogue might almost be called a short treatise on Rope, and it contains much interesting information on the making and uses of the best quality of rope, the latter including its use in transmitting power. Like the others, it is well illustrated.

Catalogue, Dodd's Sigmoidal Water Wheel. The Pacific Iron Works, San Francisco.

BOOKS RECEIVED.

Irrigation Statistics of the Territory of Utah. Compiled by Charles L. Stevenson, Secretary of Utah Statistics Committee. This is a valuable compendium, specially prepared for the Irrigation Congress at Salt Lake.

Cornell University, Agricultural Experiment Station: Bulletin 31. Ithaca, N. Y.; published by the University.

Tide Tables for the Atlantic Coast of the United States for the Year 1892. Washington; Government Printing Office. The United States Coast and Geodetic Survey, by which these Tables are prepared, desires to call attention to the fact that copies can be obtained at 25 cents each. Agencies for their sale are established in all the principal seaboard cities.

Proceedings of the Engineers' Club of Philadelphia: Volume VIII, No. 3, July, 1891. Philadelphia; published by the Club.

ABOUT BOOKS AND PERIODICALS.

READERS will find in the OVERLAND MONTHLY for October a very interesting description of the new Leland Stanford University, its foundation and objects. Other articles are on the Fruit Canning Industry in California; the first Public School in California; the Chinese Army, and the Olive in America. The last-named paper shows the possibilities of olive culture and the extent to which it has been undertaken on the Pacific Coast. Besides the articles named there are several short stories and sketches, some of them very good.

Perhaps the more striking articles in the ECLECTIC for October are Sir Alfred Lyall's on Frontiers, from the *Nineteenth Century;* Mr. Christie Murray's on Australia, from the *Contemporary Review;* Colonel Knollys' on the Diamond Mines of South Africa, from *Blackwood's Magazine,* and one on Electrical Evaporation, from the *Saturday Review.* Other articles given in this number are from *Temple Bar,* the *Westminster Review,* the *Fortnightly Review,* the *New Review,* the *National Review,* the *Spectator,* and the *Athenæum,* showing a wide range of choice.

The September number of the BULLETIN of the American Geographical Society has papers on the Native Copper of Michigan, by E. B. Hinsdale; on the Flooding of the Colorado Desert, by B. A. Cecil Stephens; on Northern Mexico, by Carl Lumholtz, and very careful reviews, by George C. Hurlbut, of Büttikoffer's Liberia and Garcia Cubas' Mexico. The Notes include an account of the International Geographical Congress at Berne.

Among the topics discussed in the ARENA for October are Healing through the Mind; Weak Spots in the French Republic; Leaderless Mobs; Theosophy; Nationalism, and the Microscope. This list does not include all the articles, but only the leading ones. No other magazine discusses such topics or with so much freedom as this, which has well earned its name.

In the COMPASS for October there are articles on Linear Measurements in the Field, on the Plain Transit, on Instrument Adjustments, and on Speedy Calculators. The very

interesting article on Series of Numbers is continued, the present part showing the application of the principles treated in the article in the slide-rule.

The paper formerly known as the *Journal of Car Heating* has taken a new departure, and will hereafter be known as the RAILROAD CAR JOURNAL. Its field will be somewhat extended, as expressed in the new title, and will include the construction and operation of cars, as well as their heating and lighting. It is a well-edited paper, and the October number—the first under the new name—presents much interesting matter. We wish our contemporary all success.

Among the books now in preparation by John Wiley & Sons, New York, are the MANUAL OF MINING, by Professor M. C. Ihlseng, of Golden, Col., a high authority. The same firm have also in hand Mr. J. G. A. Meyer's book on MODERN LOCOMOTIVE CONSTRUCTION, an enlargement of the articles published in the *American Machinist* last year.

The POPULAR SCIENCE MONTHLY for November contains Mr. Durfee's final paper on the Manufacture of Steel. Mr. Carroll D. Wright continues his Lessons from the Census, and Professor Goodale tells of some of the possibilities of Economic Botany. Professor Henderson's paper on University Extension describes the latest educational movement of importance.

Among the books announced for early publication by Harper & Brothers, New York, are Mr. Theodore Child's SPANISH AMERICAN REPUBLICS. The papers by Mr. Child in *Harper's Magazine* attracted much attention, and in book form they will be of permanent value. Another work, which will interest military men, is the WRITINGS AND MEMOIRS of Field Marshal Von Moltke, prepared from the voluminous records left by the great soldiers.

The Mississippi National Guard is described by Lieutenant R. K. Evans in OUTING for October. The Indian Territory, the Pacific Coast, the Eastern Seaboard, the Upper Peninsula of Michigan, and the Rocky Mountains all find place in its articles of travel and sport. No magazine has made so great an improvement in its illustrations recently as OUTING, both in number and quality. In the October number—in Studies in Black—there are three cuts which are by far the best representations of negro children we have ever seen in print; and there are other illustrations which deserve special commendation.

The NORTHWESTERN MECHANIC, published in Minneapolis, has been transferred to Messrs. Cooper & Hampton, who propose to make it a journal which will record the progress of mechanical engineering generally, following no special field. With the change many improvements are to be made.

The LOCOMOTIVE ENGINEER, which has been for some time issued by the *American Machinist* Publishing Company, has been sold by that Company to Messrs. Angus Sinclair and John A. Hill. Mr. Hill has been connected with the paper for some time, and Mr. Sinclair is well known as Editor of the *National Car-Builder* and Secretary of the Master Mechanics' Association. The LOCOMOTIVE ENGINEER has always been an excellent paper, bright and lively, and under the new management it cannot fail to improve.

The final article of the Steamship Series in SCRIBNER'S MAGAZINE appears in the November number; it is by John H. Gould, and is on the Ocean Steamer as a Freight Carrier. The French Trans-Saharian project is described in another paper by M. Napoleon Ney, and Lieutenant A. B. Wyckoff writes of the Naval Apprentice System. Among other articles are papers by Mr. Carl Lumholtz on his explorations in the Sierra Madre in Mexico, and by Alfred Deakin on the Federation of Australia.

In the number of HARPER'S WEEKLY for October 3 there was an illustrated description of the opening of the St. Clair Tunnel; also of some of the sailing ships of large carrying capacity lately built. The previous number had an interesting account of the cable road on Broadway in New York. In the issue for October 10 the work of the Agricultural Department's rain-makers in the Southwest is described and illustrated, and there is also an account of the improvements in progress in the Delaware River navigation. In the number for October 17 the French cod fisheries in Newfoundland are illustrated.

SOME CURRENT NOTES.

SINCE the article in the October number of the JOURNAL (page 455), on the increased strength obtained by oil-tempering and annealing steel forgings, was published, we have received particulars of another test. In this case a steel crank-pin was taken, the chemical analysis being as follows: Carbon, 0.050; manganese, 0.060; silicon, 0.150; phosphorus, 0.035. A specimen ½ in. in diameter and 2 in. between marks, cut longitudinally from the pin, after treatment stood the following tests: Tensile strength, 112,040 lbs.; elastic limit, 61,170 lbs.; elongation, 20.55 per cent.; contraction of area, 45.53 per cent. These are notable results.

THE Committee on Safety Appliances appointed at the last yearly Convention of Railroad Commissioners will hold a meeting November 10 next, at 10 A.M., in the rooms of the Chamber of Commerce, No. 34 Nassau Street, New York, to consider the subject of safety appliances, in accordance with the resolutions adopted at the Convention, which instructed the Committee to urge upon Congress the need of legislation for the adoption of uniform safety couplers and train brakes.

The Committee specially request that all organizations of railroad employés and officials have representatives present to give their views on the subject of Federal regulation of safety appliances on railroads.

The Committee consists of the following Commissioners: George C. Crocker, of Massachusetts; James C. Hill, of Virginia; Spencer Smith, of Iowa; William E. Rogers, of New York; John H. King, of South Dakota. The Secretary is Mr. Edward A. Moseley, of the Interstate Commerce Commission.

ONE of the largest relief maps in the world has been prepared by Professor Edwin E. Howell, of Washington, from data furnished by the United States Coast and Geodetic Survey. It represents the United States, and is molded on a section of a globe 133 ft. in diameter; the map itself is 6 ft. 6 in. × 4 ft. in size. The horizontal scale is 1 in. = 50 miles, and the vertical scale 1 in. = 5 miles.

WORK is to be actually begun on the first elevated railroad in Philadelphia intended solely for city travel. This is the Northeastern Line, which is to run from Market Street northward to Frankford. A contract has been let for the building of the road from Market Street to the corner of Amber and Norris, and bids are in for the rest. The structure will be similar to the Sixth Avenue Line in New York, the tracks being carried on girders extending across the street and resting on pillars placed at the edge of the sidewalk. The Phœnix Bridge Company is to build the road.

AN important dam across the Androscoggin River at Rumford Falls, Me., has just been completed. Its object is to improve the water-power at that point. This dam is 440 ft. long, 56 ft. wide at the bottom, and about 20 ft. high. It is built of large timbers laid up in crib-work and the cribs filled with stones and covered with 4-in. hardwood plank. On the up-stream side the structure is covered with gravel, and on the down-stream side it is protected by a broad apron of heavy planking. The head-gates are set in masonry.

ONE of the largest irrigation systems in this country is in the Pecos Valley in New Mexico. It already includes 120 miles of main canals and 100 miles of laterals, and plans have been prepared for extensions which will irrigate 160,000 acres of land. The water is taken from the Pecos River and the Rio Hondo, and a large storage reservoir has been established on the Pecos, where a lake seven miles long, 1¾ miles wide, and holding about 1,000,000,000 cub. ft. of water has been formed. The dam here is 40 ft. high, 175 ft. wide at the base, and 1,140 ft. long. It is chiefly of limestone and has on the upper face a layer of earth 6 ft. thick, covered with riprap. The main canal from this reservoir is 7 ft. deep, 45 ft. wide at bottom and 70 ft. at the top.

SOME important tests are in progress at the Army proving ground at Sandy Hook. They include those of the 10-in. guns, of the new mortars, and of the pneumatic disappearing carriage for the 10-in. gun. The greatest delay in the trials so far has been caused by the difficulty in getting a full supply of powder.

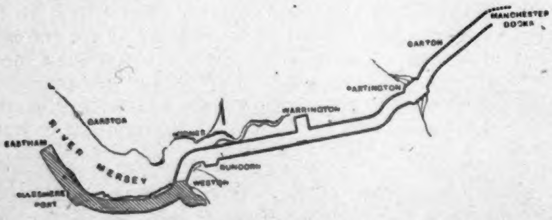
THE proposed tests of American steel armor-plates have been delayed a little by lateness in delivery, but are expected to be made in November. One object will be to determine the advantages of nickel alloy in steel and of the Harvey process of treatment.

IT is now stated that Mr. Edison has devised a new electric motor, which will do away with the objectionable overhead wire entirely, the electrical current being sent through the rails. We are also told that this motor can be applied on long lines, and a speed of at least 100 miles an hour is promised us. Mr. Edison hopes soon to be ready to test this motor in actual service.

THE total freight movement through the Sault Ste. Marie Canal in September was 1,388,333 tons, showing an increase of 8¾ per cent. over September, 1890, notwithstanding the fact that there was a decrease of 10 per cent. in the iron ore traffic. The variety of the traffic will be seen from the statement that the leading items of freight were 621,316 tons of iron ore, 351,517 tons of coal, 548,115 barrels of flour, and 5,928,840 bushels of wheat.

ON October 1, according to the tables of the *American Manufacturer*, there were 305 furnaces in blast having a weekly capacity of 180,818 tons; an increase of 1 per cent. in number of furnaces, and of 3½ per cent. in capacity during the month. As compared with October 1, 1890, there was a decrease in the number of furnaces at work, but an increase of 4,035 tons, or 2¼ per cent., in capacity. The increase has been largely in Southern furnaces.

THE water has been let into the second section of the Manchester Ship Canal, extending from Ellesmere Port to the mouth of the River Weaver, a distance of seven miles. There is now a waterway in the canal for 11 miles, from Westham Marsh locks to the Weaver River, and vessels bound for the upper Mersey pass through it. The accompanying sketch, from *Industries*, shows the completed



portion of the canal, which is shaded in the plan, the unfinished portion being also shown, unshaded. On the incomplete sections, however, a large part of the work has been done.

THE reports of the consulting engineers of the New York Rapid Transit Commission have been made public. The engineers—Messrs. Octave Chanute, John Bogart, Theodore Cooper, and Joseph M. Wilson—present separate reports, none of them fully approving either of the plans before the Commission. Mr. Chanute's report, which is especially full and minute, recommends a combination of the parallel and separate tunnel plans, with some changes to secure greater facilities in operating the proposed lines.

THE race between the steam launches *Norwood* and *Vamoose*—for each of which the claim to be the fastest vessel in the world has been put forward—has been postponed on account of an accident to the *Norwood*, so that the question of their respective speed must remain undecided for the present. Both boats are simply racing machines, being of no use even for pleasure boats, since the engines and boilers occupy all the available space, so that the contest between them will be of no practical service—except, perhaps, to show how great a weight of machinery a small boat can be made to carry.

SOME carefully prepared statements as to the cost of operating street railroads were submitted to the Street Railroad Association recently. According to these, the cost of carrying each passenger—taking the average of a number of roads of each class—was 3.55 cents with electric motors; 4.18 cents with horses, and 3.22 cents on cable roads. Including interest on cost of road, the averages were: On electric roads, 4.53 cents; with horses, 4.98 cents; on cable roads, 4.77 cents. The great difference is on the cable roads, when interest charges on a costly plant are included. That a cable road is by far the highest in first cost every one knows; that it is not the best fitted for a city where there is large traffic, many will be disposed to doubt.

THE London *Iron* says that the firm of Esscher, Wyss & Company, of Zurich, Switzerland, have completed a launch 20 ft. long and 5 ft. wide, driven by a 2-H.P. naphtha motor. The peculiarity of this boat is that she is built entirely of aluminum, even to the engines and propeller, being the first vessel in the world so constructed. She has made one or two successful trial trips.

THE railroads of the Argentine Republic are in a bad condition, owing to the general depression of business in that country, and in part also to the refusal of foreign boards of directors to reduce rates or accommodate the management in any way to the present state of affairs. Under these conditions the Government is already called upon to make large payments under the guarantees given to some of the companies, while further sums will soon be required. The foreign control of the roads is really proving at present a serious injury, both to the country and to the railroads themselves.

IN the Columbian Exhibition at Chicago England and Germany have each secured an equal space, 40,000 sq. ft., for machinery exhibits.

The Illinois exhibit will include a number of topographical maps, specially prepared for this purpose. One will show the water-courses and another the railroads, in addition to the general topography.

The old Hackworth engine *Samson*, now in Nova Scotia, will be in the Department of Transportation, with a facsimile of a passenger car of 1832.

Mr. Willard A. Smith made an excellent address in behalf of the Transportation exhibit before the Superintendent's Association.

RAPID TRANSIT IN NEW YORK.

THE Rapid Transit Commissioners—Messrs. William Steinway, John H. Starin, Samuel Spencer, John H. Inman and Eugene L. Bushe—who have been considering the question of new passenger lines in New York for some months, made their report public on October 20. As anticipated by previous partial statements, it recommends a line from the Battery northward under Broadway to Union Square (14th Street), where this main trunk is to divide, the western branch proceeding under Broadway

and its continuation, the Boulevard, to Spuyten Duyvil Creek near Kingsbridge and thence northward to the city line. The eastern branch will run from Union Square under Fourth and Madison avenues to 96th Street and thence through private property between the avenues to the Harlem River, and crossing the river, continue northward to Jerome Park.

From the Battery to City Hall three tracks are proposed ; at City Hall a loop line will be introduced, so that trains can be turned there without reversing them. From that point northward to Union Square there will be four tracks in tunnel, and on the west side this four-track tunnel will continue to 121st Street. At that point there is a sharp depression of the surface, and the line will be continued on a viaduct to 156th Street, where it will again enter a tunnel for a short distance, and the extension to the city line will be alternately on viaduct and in tunnel, according to the nature of the surface. The four tracks will continue to the Spuyten Duyvil crossing, from which point there will be two tracks only.

On the east side line the viaduct construction will begin at 96th Street and continue to the Harlem River, but north of that point the road will be for some distance underground and then alternately tunnel and viaduct, as the surface is undulating. On this line also four tracks are proposed to the Harlem River and two tracks beyond it.

Perhaps a fuller explanation will be given by the following extract from the report of the Commission itself :

HOW CONSTRUCTED.

The general plan of construction of the loop under Battery Park, State and Whitehall streets shall be double track ; from the Morris Street junction to near Vesey Street shall be three parallel tracks on the same level, with suitable switches and connections between them ; from Vesey Street to 190th Street, on the west side line, shall be four parallel tracks on the same level, and thence across the Government ship canal and Spuyten Duyvil Creek to the city limits shall be two parallel tracks on the same level. On the east side line from 14th Street to the Harlem River shall be four parallel tracks on the same level, and thence to the city limits shall be two parallel tracks on the same level. The tunnels shall be not less than 11 ft. 6 in. in height in the clear, and 11 ft. in width for each track. Whenever necessary for the proper support of the surface of the street, the roof of the tunnel shall be of iron girders, with solid plate iron covering, supported by suitable iron columns between each of the tracks, and supporting walls on the outside. The roof of the tunnel shall be as near the surface of the street as the pipes and underground structures now laid therein and the street grades will permit. Viaducts shall be of masonry or iron, or both combined. The Government ship canal and the Harlem River shall be crossed by double track drawbridges not less than 50 ft. in the clear above mean high-water mark, with clear spans of not less than 125 ft. between the center piers and bulkhead line.

NORTH OF THE HARLEM.

North of the Harlem River the construction shall be by viaduct, depressed structure and tunnel as the grades of the land upon the proposed routes shall require. The junction of the tracks near 14th Street shall be effected by dividing them around Union Square, raising one pair and depressing the other, so that trains going in opposite directions shall not cross on the same level. All station approaches shall be as far as possible through private property to be acquired for that purpose, except that on the Boulevard station approaches may be in the center of the street.

A footway shall be provided the whole length of the line between the center tracks, and refuge niches shall be built in the side walls at proper intervals for the convenience and protection of employés.

The motive power shall be electricity or some other power not requiring combustion within the tunnel ; and the motor or motors shall be capable of a uniform speed for long distances of not less than 40 miles per hour, exclusive of stops.

The manner of construction from South Ferry to about 34th Street shall be by underground tunneling without disturbing the surface of the street. In case of necessity the excavations below Beaver Street and in the neighborhood of Canal Street, and at such other special points as this Commission may during the progress of the work determine, may be made by excavation from the street surface, and all excavations in Fourth Avenue, above 14th Street, and in all other streets and avenues above 34th Street may be made in the same manner.

THE BATTERY LOOP.

A loop at Battery Park is adopted as furnishing the best and most convenient method for the terminal handling of the trains, both way and express.

The three tracks between Bowling Green junction and Vesey Street provide amply for the volume of traffic below the City Hall, and avoid encroachment beyond the curb line in Broadway at its narrowest points.

The introduction of a loop at City Hall Park by which trains may be stopped, turned and despatched up-town continuously and without switching and without grade crossings, for trains in opposite directions, furnishes the best means of a second downtown terminus at the most important point, and the best means of connecting with the Brooklyn Bridge.

At Union Square a system of tracks has been devised by which all trains on the Broadway and Madison Avenue line are accommodated at a single station, and all grade crossings between trains in opposite directions are avoided, thus facilitating high speed and eliminating in the best manner possible the dangers and delays incident to such crossings.

At 96th Street the contour of the ground necessitates the termination of the tunnel. It, therefore, became necessary to deflect the line from Madison Avenue and occupy private property, thence to the Harlem River, on account of the prohibition in the Rapid Transit act against the use of Madison Avenue for an elevated structure.

The stations on the route selected have not been located, for the reason that the Board was advised that they constitute part of the detailed plans which the Commission are required to complete after the general plan shall have received approval.

Detailed plans and specifications for the construction of the railroad, including stations, devices, and appurtenances deemed necessary to secure the greatest efficiency, public convenience, and safety will be prepared by the Commission in accordance with the provisions of the act, if this report is approved.

NOT LIMITED BY METHODS.

The Commission make no recommendations as to the method of construction. These matters the Commission will deem it wise to leave, so far as permitted by the act, to the judgment of the purchaser, subject always, as the act requires, to the control of this Board. The particular shield, if any, to be used in excavating under the streets, the details as to materials and form of walls and other interior surface should, as far as consistent with the requirements of the act, be subject to his selection. Any attempted determination of the method of construction in advance might narrow the field of possible competition to such an extent as to endanger the success of the enterprise.

When the Commission decided to adopt an underground route it also decided that the motive power must be secured without combustion in the tunnel.

Much attention has been devoted to the consideration of electricity as a motive power. Consultations have been held with eminent electricians ; experiments have been witnessed ; electric roads in operation have been examined.

While the Board is convinced that electricity as a motive power is available for the purposes of the railroad recommended by this report, it is not deemed wise at the present time to exclude other forms of power answering the essential conditions of speed and non-combustion in the tunnel, or to attempt to direct the exact method of application of such power as shall finally be adopted.

This report approves and presents what has been known as the Worthen plan, for four tracks on a level, as opposed to the Parsons plan, by which two tracks for express trains were to be placed below the two way tracks, in separate tunnels. The deep-tunnel plan, which proposed a line 50 or 60 ft. below the surface, was considered and rejected, for reasons given in the report.

This report is submitted under the law to the Board of Aldermen ; if approved by that body the Commission will proceed to make all plans required, and then to arrange for the organization of a company to build the road. After a corporation is formed stock subscriptions will be invited in the usual way. It will be seen, therefore, that there is still much to be done before the plans are carried out.

The cost of building the lines will be very great, but there can be little doubt that they will become a paying property in time. There is certainly no doubt that public convenience requires them.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS. XXIII.—SOAP.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page* 455.)

THE article on spring steel is still necessarily postponed. In this article we will treat the subject of SOAP and DETERGENT.

The necessity for some control over the soap and detergent used on a railroad is, perhaps, hardly obvious at first sight, but as the subject is studied more, it will become evident, we think, that the matter is one of a good deal of importance, and that a good deal of money, in one way or another, leaks away if soaps and detergents of the right kind are not used.

It is perhaps hardly necessary to say, since the matter is one of so common knowledge, that soaps in general are simply soda salts of various organic acids. These acids are generally obtained from fats or rosin. Ordinary fats, as is well known, and as has frequently been explained in the course of these articles, contain acids combined with glycerine. This is true to a greater or less extent, if we may trust the work already done as a guarantee for the whole ground, of all the fats, whether animal or vegetable —that is to say, nearly all of them are some characteristic acid or acids combined with glycerine or some cognate body. The acids, taken as a whole or class, have been called fat acids, since they are characteristic most largely of fats. Of course a scientific classification would not group them all together, since they belong to several different series of chemical bodies.

If, now, the glycerine in any of the fats is replaced by either soda or potash, a resulting compound is formed, which, so far as our knowledge goes, is soluble more or less in water, and this compound we call soap. If any other base than soda or potash is used, the material may or may not be soluble in water. For example, if lime or magnesia or lead or zinc is used, corresponding lime, magnesia, lead, or zinc soap is formed, some of which have valuable properties and uses in the arts. They are not, however, valuable as detergents. A soap for detergent purposes is practically, therefore, as said above, a soda or potash salt of some one or more of the acids from fats and rosin. This seems exceedingly simple, and it would seem as though nothing could occasion less cause for difficulty than a soap which is so simply and easily made and is such a simple substance in itself. Unfortunately, however, in the actual practice of making soaps two or three difficulties arise. First, depending on the kind of acids used, and whether the alkali is soda or potash, the soap is either hard or soft. The potash soaps are in general softer than the soda soaps. Fortunately a soft soap is usually not desired, except possibly for household purposes, and as potash is much more expensive than soda, potash soaps usually are not made for the market very largely. On the other hand, even with potash and with certain kinds of fats a good hard soap can be made. Still, again, if certain acids are used and soda is the alkali, a soap too soft for general use results, so that the art of the soap maker, so far as material is concerned, consists largely in first of all using the cheaper alkali—namely, soda, and then so selecting his acids that a soap of the proper consistency will result. It is just here that a good deal of difficulty occurs. Those acids which will make soaps sufficiently hard are more expensive, while, on the other hand, the very cheap acids, notably rosin, make a soap too soft for general use. This difficulty of making a soap cheaply and at the same time making it hard enough has led to a modification of the process, which is all right apparently for the soap maker, but which is all wrong for the consumer. It has been found by experiment that more or less sal soda, otherwise known as washing soda or carbonate of soda, put into a batch of soap hardens it, so that if such materials are used as would give a soap too soft for ordinary use, the presence of one or two or three per cent. of sal soda will sufficiently harden that soap so that it will be a marketable article. The presence of this sal soda, as will be explained a little later, is one of the causes of difficulty in the use of soaps on a railroad.

Many of the soaps of the market likewise contain another element which is a matter of a good deal of annoyance in their use. As stated above, soaps are simply a chemical combination of caustic alkali with fat acids. If the acids are in the free state the combination takes place very readily, the alkali being put in water solution in contact with the acids, and with low temperatures the combination takes place readily. If the fat acids, however, are still combined with their glycerine—which is the case with many of the good fats—the saponification, which consists in crowding out the glycerine by the soda, takes place more slowly, and higher temperatures and longer time are involved. The resulting compound of soap, even at the temperatures of manufacture, is a viscous material, and it is a matter of some little skill to get the last traces of the fat and the alkali together. This difficulty is diminished somewhat, if we understand the matter rightly, by an excess of alkali—that is, more alkali is used than is absolutely necessary to completely saponify the fat. Furthermore, it is claimed by some soap manufacturers that they cannot sell a soap unless it "takes hold" pretty well, as it is called, and to make a soap pretty vigorous in its action leads them still further in this matter of adding an excess of alkali. It is this excess of caustic alkali, which gets into the soap from either one or both of the above causes, which makes the soap so detrimental to the consumer. Two things, then, in soap are bad for the consumer—namely, large amounts of carbonated alkali and a large excess of caustic alkali.

Just at this point the question may fairly arise why it is that these two things are bad for the consumer. Is it not true, it may be asked, that all the detergent action is due to the alkali of the soap anyhow, and what harm is it if there is a little excess? We hardly feel inclined to go into a discussion of the action of soaps as detergents. Even though we allow that the cleansing action of soaps is due to the alkali which they contain, and all our knowledge seems to point in this direction, we are still unprepared to admit that the excess of caustic alkali and the presence of the carbonated alkali is advantageous, and for the following reasons.

A number of years ago a car on the Pennsylvania Railroad was cleaned on the outside by the car cleaners, they removing the accumulation of dirt arising from the smoke and cinders which had collected on the surface of the varnish. This car was required for a special purpose, and accordingly fell under the eye of one of the officers, who noticed that the car looked very badly. He ordered the car sent to shop for an examination by the Foreman of painters, who reported that the varnish had practically been ruined by the car cleaners; that in their zeal to get

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona.

The articles will contain information which cannot be found elsewhere. No. I, in the JOURNAL for December, 1889, is on the Work of the Chemist on a Railroad; No. II, in the January, 1890, number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the Method of Purchasing Oils; No. IX, also in the July number, on Hot Box and Lubricating Greases; No. X, in the August number, on Battery Materials; No. XI, in the September number, on Paints; No. XII, in the October number, on the Working Qualities of Paint; No. XIII, in the December, 1890, number, on the Drying of Paint; No. XIV, in the February number, on the Covering Power of Pigments; No. XV, in the April number, on How to Design a Paint; No. XVI, in the May number, on Paint Specifications; No. XVII, in the June number, on the same subject; No. XVIII, also in June, on the Livering of Paint; No. XIX, in the July and August numbers, on How to Design a Paint; No. XX, in the September number, on Disinfectants; No. XXI, on Mineral Wool, and No. XXII, on Wood Preservative, both in the October number. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION of special value.

the dirt off they had taken off nearly all the varnish. The Foreman of car inspectors was called to account for this abuse of detergent materials, since, of course, it is a very serious matter to have the varnish on a car destroyed during the cleaning operation. This foreman replied that he could not do better with the soap furnished them. He was then asked for a sample of the soap, which was subjected to analysis, and to the astonishment of all interested, the soap was found to contain not less than 3.50 per cent. excess of caustic alkali and about 7.50 per cent. carbonate of soda. This was somewhat of a revelation, but the matter did not rest here. A number of soaps were then obtained from the market and from different points on the road, all of which were subjected to analysis, and it was found that very few of them were free from excess of caustic and from carbonated alkali. From the list a series could be culled out differing from each other in excess of caustic and carbonate, and from these samples wafers were cut out about one inch in diameter and an eighth inch thick. A direct and positive experiment was then made with each of these different soaps, to see what the effect was on the varnish. A carefully prepared varnished surface was secured, and at different points on this surface a globule of water was placed. Over the tops of the globules of water were laid the wafers above mentioned in the series. Each separate test was covered, to prevent evaporation, and the whole thing allowed to stand until morning, when an examination was made. At one end of the series was a soap which was almost absolutely neutral—that is, had almost no excess of caustic and no carbonate. At the other end of the series was the very bad soap mentioned above, containing a large excess of caustic and a good deal of carbonate. The intermediate samples varied in the proportions.

On removing the wafers of soap from the varnished surface, it was found, beginning at the bad end, that the varnish and paint had all been dissolved clear down to the wood, the next one was a little less bad, the next one still less, and finally at the end, which had the neutral soap, the action was slight, not even reaching through the varnish, although the exposure had been for something over twelve hours.

It has been known for years that both paint and varnish are readily dissolved by caustic alkali, and this experiment was relied on to prove that the use of soaps in practice which contain large amounts of free alkali and large amounts of carbonated alkali are detrimental.

The same reasoning applies to a greater or less extent to the use of soaps for the toilet. If there is a large excess of carbonated and caustic alkali, the use of these soaps will usually result in detriment to the surface washed. Sore hands and injury to clothing, if we may trust our studies, are largely due to the use of soaps containing too great an excess of alkali, either free or carbonated.

Just at this point it is essential, we think, to make a clear distinction. We think there is very little doubt but that soap containing large excess of caustic alkali and large amounts of carbonated alkali may be used in such a way that no very serious detriment will result. Chemical action takes place under many circumstances in proportion to the length of time the substances are in contact. If, now, a soap rich in excess of caustic alkali and in carbonated alkali is used, and the soap is left on the surface only a short time, it is entirely possible the detergent action desired may be obtained without the deleterious action on the varnish. Again, in washing the hands or in washing clothing, if a strong solution of alkali is not kept too long in contact with the hands or too long in contact with the clothing, no serious injury will result; and especially so far as hand and face washing are concerned, if the last traces of alkali are removed from the surface by the subsequent operation of drying the hands and face, it is probable no serious difficulty will result. Indeed, we are inclined to the view that even pure caustic alkali in not too concentrated solution, and also sal soda solution not too concentrated, may be used as detergents without any injury to the surfaces cleansed. The unfortunate part of the matter is that it is simply impossible to get such intelligent use of such dangerous materials as will not result in great loss and damage to the surfaces cleaned. We are free to confess that if all people would use soaps or even sal soda and caustic soda in the proper way, the detergent action desired could be obtained without serious injury to the surfaces; but we have never seen any car cleaner, or any laundry women, or, indeed, any person washing his hands and face who is willing to take the requisite care to use these powerful detergents in such a way that they would not be apt to cause difficulty. The whole philosophy of soaps is such a modification of the detergent action of the alkalis as will make them usable by ordinary people without danger of injury. We have accordingly prepared and have in force on the Pennsylvania Railroad specifications for soap, both common and toilet, and aim in these soaps to secure a material containing the least possible excess of caustic alkali and as little as possible of the carbonated alkali.

One or two points farther in regard to detergent action. Soap is apparently not the only substance that has detergent properties. Glycerine alone is a fairly good detergent, at least, under many conditions, and we have made a number of experiments which rather indicate that sugar solution in a moderately concentrated condition is likewise something of a detergent. The well-known glycerine soaps are examples of attempts to combine with the ordinary soda soap the detergent properties of both glycerine and sugar. Many of the so-called glycerine soaps in the market contain both glycerine and sugar, most commonly sugar, since it is cheaper. Not all the transparent soaps, if we may trust our experiments, are glycerine soaps, and very few of them with the same precaution—namely, if we can trust our experiments—contain anything like the amount of glycerine which they are advertised to contain. In view, however, of this possible and very likely desirable detergent action of the glycerine and sugar, we prepared our specifications so as to admit these soaps, and recognize these elements as detergents, and pay for them. It should, perhaps, be added that there is a belief in general that glycerine on the hands has a valuable emollient and soothing influence, preventing the skin from becoming rough and sore. We are not at all prepared to affirm or deny this belief, simply mentioning it to show that we recognize this as one of the possible values of a soap, and that consequently, as said above, we have prepared our specifications so as to admit glycerine in toilet soaps.

One point farther in regard to toilet soaps. We do not feel willing to declare that all soaps which give sore hands necessarily contain large amounts of free alkali, or, in other words, we have some evidence which indicates that soaps which are unobjectionable so far as free alkali is concerned cause difficulty with the hands. On the other hand, we have not succeeded in finding anything in the soaps complained of which would explain the phenomenon, and while we do not feel willing to say that soaps may not contain impurities or other substances besides the free caustic alkali which affect certain skins deleteriously, we have not yet succeeded in finding these substances in any of these soaps, and our usual explanation has been that the parties who complained of the soap failed to sufficiently dry their hands after washing.

In view of the injurious action of not only the best soaps, but especially soaps which contain an excess of caustic alkali and carbonated alkali, we have spent some time and study in trying to find some detergent or some method of car cleaning which would be less injurious to the paint and varnish. Quite a number of materials have been offered to us for this purpose. Not a few liquids have been recommended, sometimes under high-sounding names, as proper materials to use for the cleaning of our cars. We have carefully examined each of these substances as it has come forward, because, as will readily be recognized, the varnishing of cars is expensive, and it is desirable to have the varnish wear as long as possible, and if it will only stand one or two cleanings, the cars look badly a good deal of the time. Most of the liquid detergents which we have examined contain some substance as the characteristic one which dissolves the varnish. We have not yet succeeded in finding one which did not do so. Some of them contain ammonia, and, as is well known, ammonia dissolves varnish readily. Some of them contain caustic soda in solution, and this has already been

described as hurtful to varnish. Some of them contain nitro-benzol, which is a very good solvent of varnish, and so on. It is fair to say that it seems almost impossible to think of any method of cleaning a varnish which has dirt lying on it without removing at the same time a portion of the varnish, since the connection between the dirt and the varnish is so intimate. What is desired is to get the dirt off and leave the varnish behind. Of course, if some solvent was known which would dissolve the dirt and would not dissolve the varnish, the problem would be solved. Unfortunately in the case of cars, much of the dirt is either mineral matter or carbon from the coal smoke or particles of coal from the smoke-stack, which have impinged against the varnish so tightly as to imbed themselves, and for these substances we know of no solvent. It is absolutely essential, therefore, in order to clean a varnished or painted surface, that a small amount of the surface should always be removed with the dirt. The problem is to get a detergent which will remove the dirt with the smallest possible injury to the varnish.

We do not think the problem of successful detergents for varnish cleaning is yet solved, but we have obtained quite satisfactory results, with apparently less injury to varnish, than accompanies the use of good soap by the use of a mixture of soap and tripoli or pulverized pumice-stone. The soap and pulverized pumice-stone are mixed in the proportions of about three parts soap to seven parts of the pulverized pumice-stone, and the whole is obtained in the form of a powder. We buy this material under the name of "Detergent for Cleaning Paint and Varnish," and it is, or should be used in the dry form by means of a wet or properly dampened cloth, the cloth being first dipped into the supply of powdered soap and tripoli and then applied to the varnished surface with friction. In this case there is very slight solvent action of the varnish due to the soap, and there is also the mechanical action of the pulverized pumice-stone or tripoli, so that, if the material is properly used, a very dirty surface can be cleaned almost without interfering with the gloss of the varnish, provided the tripoli or pumice-stone is sufficiently fine. We have been astonished many times to see how slight injury the varnish receives under this treatment, and how efficient the material is if properly used.

The whole subject of cleaning paint and varnish needs more study. The best we can recommend at present is the detergent provided for in our specifications, and next to that soaps as neutral as possible, with proper care in the cleaning. It will readily be noted that the use of the detergent mentioned above might result in serious injury to the varnish, due to the soap present, provided it was not properly used. For example, if the material was put on the varnish in the form of paste and allowed to stay there for a period of time, it would, of course, dissolve the varnish more or less. If used properly, as above described, the injury to the varnish is extremely slight.

In view of the discussion above, it will probably be queried why we are so particular to keep mineral matter out of our common and toilet soaps, as is provided for in our specifications. To this we will say that the prohibition of mineral matter in soaps is more a commercial question than one of the service. We provide a place for the use of large amounts of mineral matter, and do not think it proper to allow manufacturers to load a soap with mineral matter as a make-weight.

A single thought further in regard to the constitution of soap. It is quite well-known by those who are familiar with the process of soap manufacture that common salt removes soap from water solution, which means that soap is not soluble in salt water. It is accordingly the practice of the manufacturers in making many of the cheap soaps to add at the last, after the boiling is done, quite an amount of common salt, so as to remove the water from the soap, or separate the soap from the water. This process, if we may trust our determinations, leaves in the soap more or less of the salt, which is added to the batch. It is possible this salt has a little tendency to harden the soap, but we are not sure on this point. We do know, however, that a soap containing quite a large amount of salt is inferior as a detergent, and the reason is not difficult to see. The salt in the soap mixes with the water when the soap is used, and prevents the soap from dissolving in the water as readily as it otherwise would. We have, accordingly, in our specifications limited the amount of salt that can be allowed. Some of the cheap soaps of the market contain not uncommonly 3.00 per cent., and sometimes we have found as high as 5.00 per cent. of common salt in the soap.

In the next article the subject of soap will be concluded.

(TO BE CONTINUED.)

A SUGGESTION FOR COAST DEFENSES.

BY J. C. LITTLE.

THE great extent and the defenseless condition of the sea-coast of the United States make the question of sea-coast defenses one of paramount importance to the nation. We have as yet no navy that could cope with the monster iron-clads of Europe, and no forts that could resist their fire. The maritime cities are at the mercy of a foreign fleet, and are liable to be called upon, in case of war, to pay enormous ransoms as the price of safety; the forts, with their obsolete works of stone, are really but traps for our soldiers, and our national ships are unable to cope with first-class men-of-war in action. Our main defense as yet lies in the torpedo system, and that has to be tested in war before it will be possible to tell how far it can be relied on to defend the coast and the cities. Forts that are strong enough to stop the shot of a Krupp or Armstrong gun, and prepared to return its fire with the 10-in. and 12-in. rifles now being built by the Government, are an indispensable necessity for public safety. It has been demonstrated that stone works will not do; steel and iron are too costly for such extensive structures as large forts; and the best material of all is sand or clay, since that will not fly into fragments, and thus redouble the destructive effects of the shot; while stopping the most powerful projectile is simply a question of thickness. How great that thickness need be can readily be determined by experiment.

There is another and more important question to be considered than stopping the shot. No works will be of permanent service if their guns are so exposed as to be readily disabled by an enemy's fire. It is essential that the works should be so planned as to afford the minimum of exposure to the guns, while maintaining the efficiency of their fire.

During the late War the writer was the Ordnance Officer of Fort Fisher, N. C. This fort was not an enclosed work, like Fortress Monroe and other well-known fortifications, but consisted of two sides of a roughly shaped parallelogram, the south and west being open. The east side faced the ocean, and the north side fronted upon the narrow strip of land which separates the Cape Fear River from the Atlantic. This latter line of the works was designed to guard against an attack by land; and it was upon this front that the fire of the Federal fleet was principally directed. Their fire so effectually prepared the way for the troops, that when the assault was made there was but one gun, out of 20 or 30 mounted on that line, that remained on its carriage and in condition for use, the others having been dismounted or disabled by the accurate fire of the ships, especially that of the monitors, which lay within easy range to the northeast of the fort. The gun that escaped was steadily fired at during both bombardments, and while the gunners found no difficulty in striking the other pieces, they tried in vain to disable this.

All these guns were mounted in *barbette*. The muzzles of all the others being backed by the sky, presented as pretty a mark as any gunner could ask for, and afforded to him every facility for following the flight of his shot and correcting his aim; but the gun that escaped, being backed by a tall traverse, afforded no good mark, and the shot that passed near it, plunging into the sand of the traverse, gave the gunner no indication how he should alter his aim.

From a consideration of these facts, I was led to seek

out their reasons, and have therefrom deduced a plan of works, which seems to me to give the result desired, viz: The minimum of exposure to the gun while not decreasing the efficiency of its fire. The materials employed in construction are always and everywhere accessible, being either sand or clay, whichever may be most convenient.

I consider that the essential points to be attained are: First, to mask the gun, and second, to stop the shot of the enemy. I make no attempt to secure a plunging fire, since the great range of modern guns renders the attainment of this object impracticable where the ships have open water and the beach is flat; and these are the conditions at most of the locations where works are needed.

In this article I show only the general plan. The details must be determined by experiment. I have no means of ascertaining the depth to which a modern gun will penetrate sand or clay, and the proportions of the works depend upon this factor. The works should be thick enough to stop a shot fired from any distance at which a fleet is likely to engage. The plan is drawn with an angle of slope of 15°, which gives a proportion of height to base of about 5 to 19, or an elevation of about 25 in a distance of

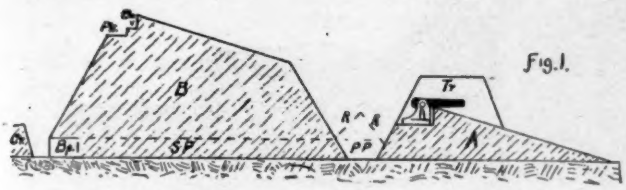


Fig. 1.

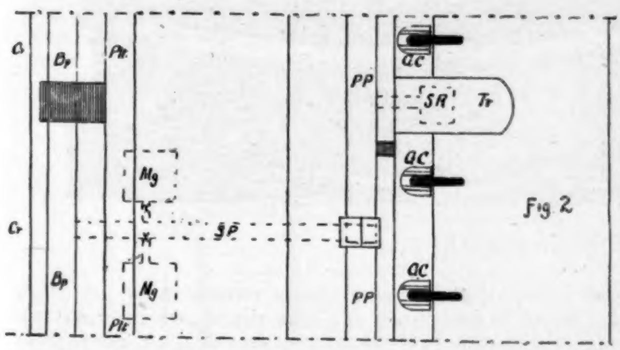


Fig. 2

95 ft. Greater thickness can be secured either by diminishing the angle of slope or by increasing the height of the works.

As shown in the plan, the proposed fortifications consist of two lines of works, *A* and *B*, separated by a protected passage-way, *P P*, which should be wide enough to allow the use of carts and wagons. The outer line *A* is for the guns which are mounted in *barbette*. The inner line *B* is designed to mask the guns, to stop the shot of the enemy, and prevent them from penetrating to the interior of the fort, and to afford protection to the guns in case of an assault.

On the outer works are the gun-chambers *G C*, armed with one, two, or three guns each, as circumstances make most advisable. The chambers are separated by traverses, *T r*, to protect the guns from a flank fire. The closer together and the longer the traverses the greater the protection they afford the guns, and the less the lateral range. The proper size and interval must be determined by the requirements in the case of each particular gun. Under the traverses may be constructed shot-rooms *S R*, which may be on the level of and open into either the protected passage *P P*, as shown in the plan, or the gun-chamber at the corner next the revetment. The shot-rooms and revetments should be faced on the inner side with soft iron plates or other material which will not splinter, and which will hold back the sand and prevent it from running out of place.

The inner line *B* is much thicker and higher. The slopes of the two lines are in the same straight line, to render the fire of the defense more effective in case of an assault upon the guns. Sally-ports *S P*, wherever needed, afford a communication between the interior of the fort and the protected passage *P P*. At the outer end of the sally-ports a steep ridge roof, shown by the heavy dotted line *R R*, crosses the passage, so steep as not to be available as a bridge for assaulting troops. There are sliding-doors to run across the passage and close the sally-port. These doors are pierced with loop-holes for rapid-fire guns, to sweep the passage. The eaves of the roof should project 2 ft. or 3 ft. to prevent sand, dislodged by shell and falling into the passage, from hindering the easy running out of the doors.

Under the crest of the inner line are situated the magazines, *M g*, communicating with the sally-ports by narrow passages *x*. A bomb-proof, *B p*, to shelter the troops is constructed along the bottom of the inner line, and is covered in reverse by curtains *C r*, thus affording ample and thorough protection to the troops when not in action. The crest of the inner line is fashioned into a platform, *P l t*, furnished with a Berm, *B m*, for the use of infantry and rapid-fire guns. As this crest is higher than the tops of the traverses, the approach to the works is completely swept by the repeating rifles and Gatling guns until the assaulting columns arrive at the foot of the slope, thus making it almost impossible for the enemy to carry the heavy guns. Should they do so, however, they cannot turn them against the fort, which is protected by the massive inner line, and their further progress must be made by crossing the protected passage swept by rapid-fire guns from the sally-port doors, scaling the inner line and charging up its slope in face of the garrison and their rifles, protected by the revetment of the inner line.

The heavy line behind the guns effectually masks them from an enemy at a little distance from the works. The gunner must direct his fire by the traverses. The shot plunges into the sand, leaving no trace visible at action distance by which the marksman can tell the error of his aim. The defenders are in danger only from those shots that strike at or very near a crest; and every gunner knows that a horizontal line is very hard to hit, especially when the marksman cannot tell whether he has aimed too high or too low. If the sand is thick enough, the garrison is as safe in its bomb-proof as if no enemy was in sight. The infantry platform is left unoccupied until the enemy arrives within range, and then it is manned in a very few seconds by means of the broad flights of stairs from the interior, and the rifles and Gatling guns are high enough to play upon the foe over the heads of the troops that man the heavy guns.

This plan seems to me to solve the problem with which I set out, and to afford the minimum of exposure with the maximum of efficiency. Of course the works will be stronger and the fire more effective when the fort can be located upon a hill or bluff, but this will generally be impossible on our coast. The first consideration must, of course, be to locate the works where they will most effectually command the approaches. A fort thus constructed and armed with effective guns ought to prove a formidable obstacle in the way of an attacking fleet, even of the heaviest iron-clads.

Our present stone forts can be converted into works of this description by facing the stone wall with a sufficient thickness of sand, and building the comparatively low gun-works outside of the line thus converted.

The terrific force of the 110-ton gun, given in the September number of the JOURNAL, would make it appear impracticable to erect any works that would stop such a projectile. But it should be remembered that experiment distance and action distance are two very different things. No ship is going to haul into point blank range of first-class guns. And at any range, the guns being equal, the ship is much more vulnerable than the earthworks. To damage the fort materially a gun must be struck, while nothing that floats can carry armor enough to keep out such a shot; to strike the ship anywhere is to damage her. The ship has a stationary and the fort a moving object to aim at, but this advantage is more than counterbalanced by the fact that one has a gun muzzle and the other a large man-of-war for a mark.

If thought advisable to give the guns more thorough protection when not in action, they might be mounted on

chassis so arranged as to run upon a track parallel with the revetment. This track could run into bomb-proofs constructed under the traverses at the inner end, and the guns could be kept under this cover except when their fire was needed. This would involve the necessity of very thick traverses. As a further safeguard the traverses might terminate in a sharp edge and be protected by armor strong enough to cause a shot to glance. This would, I think, be an easier and more effective way to protect the guns than mounting them on elevating carriages, although there would be plenty of room for the pits of the latter under the gun-chambers, if it be thought that this would be a better way to shield them from danger.

The advantages claimed for this plan are:

1. That it as effectually provides for the protection of the guns as is practicable without impairing their efficiency in action.
2. That the guns cannot be turned against the fort.
3. The garrison is absolutely safe when not immediately engaged in action.
4. The guns and the approaches to the fort are completely covered by the fire of the supporting troops.
5. The use of the rifles and rapid-fire guns in no way interferes with the service of the heavy battery, the two lines being independent of each other, and neither interfering in any respect with the other.
6. Nothing in the plan prevents the use of armor-shields or other additional protection to the guns.
7. A successful assault upon the works is rendered almost an impossibility, on account of the thorough command of the approaches by the small guns and rifles from the platform of the inner line.

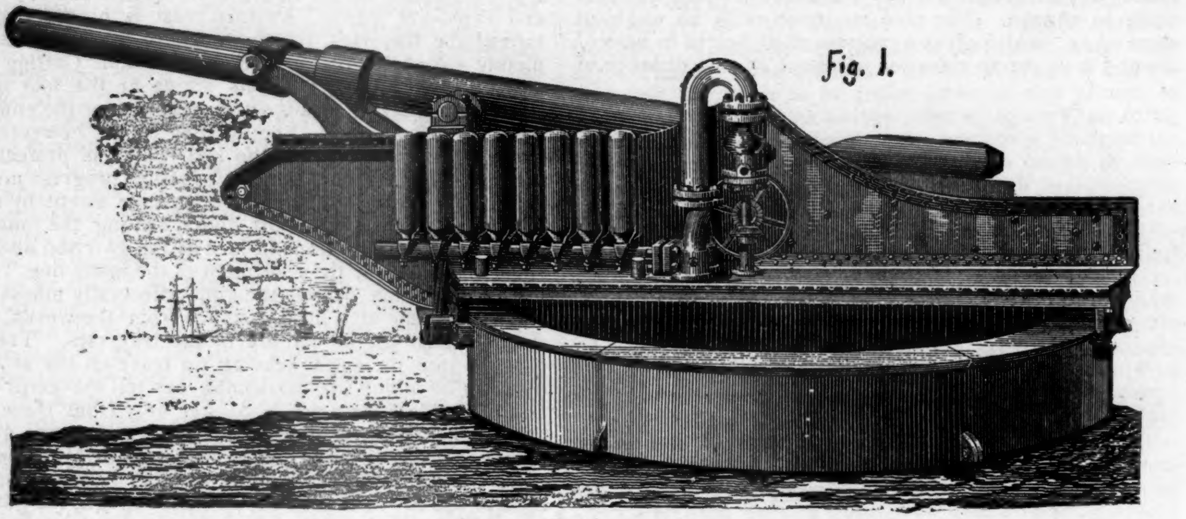
THE GRAYDON DYNAMITE GUN.

It will be remembered that some time ago experiments were made by Lieutenant Graydon with a gun intended to throw shells containing dynamite or some other high explosive with ordinary powder. The result was not altogether favorable, and Lieutenant Graydon has since prepared plans for a gun to be operated by compressed air. One of these is to be constructed abroad, and the accompanying illustrations from *Le Genie Civil* show the plan which he has adopted. Fig. 1 shows the gun carried upon a circular mount. The gun shown is intended to carry a shell charged with dynamite, and is expected to have a range of about three miles.

The gun itself is a tube of Whitworth forged steel weighing about 11 tons. It is mounted, as shown, on a carriage working on rollers on a circular track. The gun itself is provided with trunnions through a circular opening in which the compressed air is admitted. Near the mouth of the gun is a steel collar carrying two additional trunnions, which are held by two forged steel levers; and by means of these levers the elevation of the gun is altered at will, as they are worked by a hydraulic cylinder placed underneath the carriage.

The breech is closed by a screw with interrupted threads similar to those in use in the ordinary breech-loading gun. The loading is effected in any position by a small carrier mounted upon the rear of the gun carriage. This carrier is worked by two hydraulic cylinders, the cylinders being placed one on each side of the piece. By opening a valve the carrier with the shell is brought down into line with the axis of the gun, and, the two pistons continuing their movement, thrusts the shell forward into place and at the same time bring the breech screw into position.

The compressed air reservoirs are 32 in number and are disposed in groups of four on either side of the carriage, one group of them being shown outside in fig. 1. They are tested to a pressure of 4 tons per square inch and are expected to contain air at the pressure of 350 atmospheres. They are so arranged in connection with the gun that air from any number of them may be admitted to the gun at once. The reservoirs and the piston valves which regulate the discharge of the air are of Whitworth compressed steel. The reservoirs are charged from the air-compressor through pipes passing through the central pivot of the lower turret. The movement of the carriage upon the turret is regulated by hydraulic cylinders also, and it is claimed that one man can regulate the carriage, load and fire the gun. The air-compressor built for use in connection with this gun has four cylinders.



THE NEW GRAYDON DYNAMITE GUN.

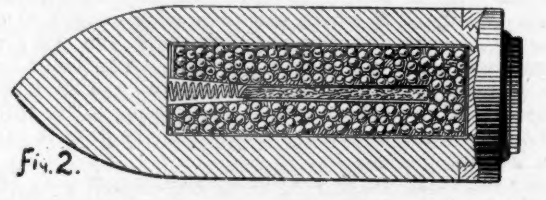


Fig. 2 shows the projectile in section. In order to prevent premature discharge, the explosive is made in small tubes or balls which are enclosed in paper saturated in paraffin. They are then placed in the cavity of the shell and separated by layers of paper. In order to secure the greatest possible penetration of the shell before explosion a spring is inserted, as shown, above the tube containing the exploder.

It is understood that an extensive series of experiments is to be undertaken with this gun in England and probably in France also.

AN ENGLISH ROAD BRIDGE.

(Condensed from *Industries*.)

THE accompanying illustrations show a bridge just completed, which carries the Great Western Road—an important street—over the River Kelvin, in Glasgow, Scotland. The bridge was designed by Messrs. Bell & Miller, Engineers, and its total cost, including land bought and a temporary structure used while work was going on, has been about $200,000. Fig. 1 is a general elevation of the bridge; fig. 2 a transverse section through one of the large arches; fig. 3 an elevation of a pier; fig. 4 is one of the

GREAT WESTERN ROAD BRIDGE, GLASGOW, SCOTLAND.

bracing frames, showing the circular openings for the water pipes.

The bridge is 60 ft. wide, and consists of two large spans of 91 ft. each, and two small spans, one of 34 ft. on the east side and one of 20 ft. on the west side. There are three piers, which occupy the site of the piers of the old bridge, and they, as well as the abutments and wing walls, are faced with granite. The piers are surmounted with handsome capitals, supporting lamps. The bridge

Fig. 2.

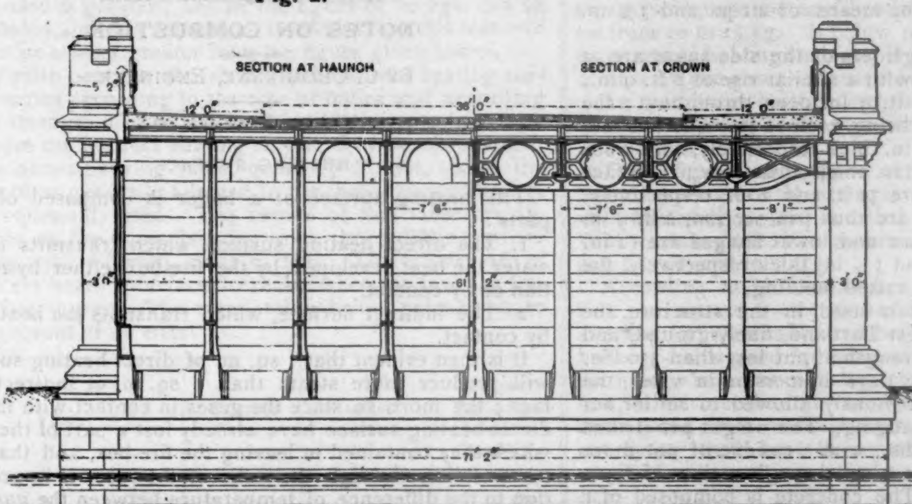
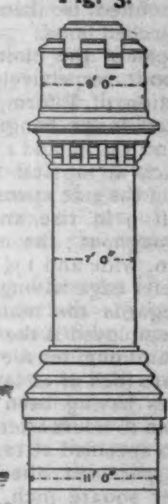


Fig. 3.



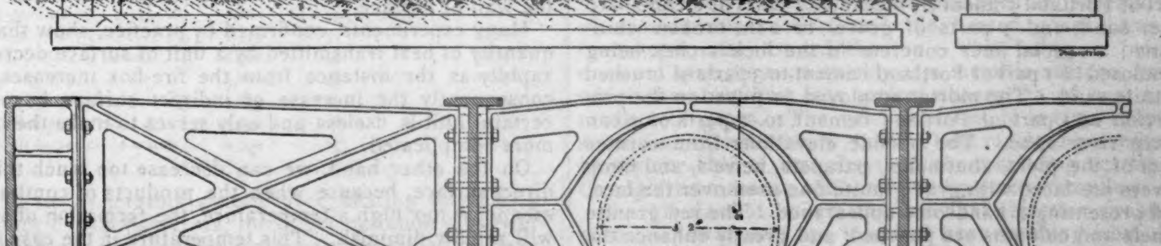


Fig. 4.

throughout is in the Gothic style, the arches being formed by cast-iron segments, surmounted by a handsome parapet of the same material. The footpaths are 12 ft. in breadth and the roadway 36 ft. The pipes conveying the water supply from Loch Katrine to Glasgow are carried across the bridge beneath the roadway.

The foundations of the structure presented no features of difficulty, both piers and abutments resting on the rock, which here comes to the surface. The Kelvin is, moreover, very shallow at the site of the bridge, and light temporary cofferdams of iron plates readily excluded the water and allowed the piers to be founded in the dry. In the case of the west abutment, the presence of coal workings beneath rendered special precautions advisable, and the cast-iron columns penetrating to the floor of the old workings, which had been put in when the old bridge was widened, were accordingly retained and utilized. These columns are connected at the top by a substantial cast-iron platform, on which the masonry of the abutment has been built. Wrought-iron frames have also, as an additional security, been bedded in the masonry of this abutment. The wing walls have footings 12 in. deep with 6 in. scarcements. The central pier rests on rock, and has a total width of 75 ft. at the lower portion and of 71 ft. from face to face of the polished granite columns.

The arches of the bridge are formed by a series of seven main cast-iron girders and two cast-iron face girders, each girder being in five segments bolted together—that at the crown having the spandrel cast on. The face girders are of a handsome and ornamental character, as will be noted from the accompanying illustrations. Each of the girders on the west pier rests upon a cast-iron framed bed-plate, fitted and bolted with 1-in. bolts to the wrought-iron girder frames, which are built into the masonry of the piers,

wrought-iron keys being fitted between the bed-plate snugs and the soles of the girders to prevent any lateral movement. The spandrels of the main girders are also of cast iron, and are in three sections bolted together, the upper flanges of the spandrels carrying the platform road beams, and being connected with the lower flanges by vertical and diagonal bracing. The cast-iron spandrels of the face girders have panels of ornamental castings and shields, surrounded by continuous moulding, the shields having armorial bearings in relief. The platform road beams are of best mild Siemens-Martin steel, and are secured by bolts to the upper flanges of the spandrels. Brick jack arches span the spacing between the road beams. The haunches of the jack arching are filled in with fine concrete to the level of the crown of the arch—viz., to the same level as the top of the platform beams.

The span of the main girders is 91 ft., the rise 18 ft. 3 in., the section being of an I form, 3 ft. deep throughout; the upper and lower flanges being each 12 in. and 15 in. wide and 1½ in. and 2 in. thick respectively, and the web 1½ in. thick at top and 1¾ in. at bottom. The span of the face girders is 91 ft., the rise 18 ft. 6 in., the section 2 ft. 9 in. deep throughout; the upper and lower flanges being 1½ in. and 2 in. respectively, and the web at top 1½ in. thick and at bottom 1¾ in., the lower outer edge being ornamented with a raised moulding. The joint flanges of the main and face girder segments are 2¼ in. thick, each joint being secured by eight bolts, 1¾ in. diameter. The main girder spandrels have upper and lower flanges 1¼ in. to 1½ in. thick respectively, the web and vertical rib being 1¼ in. thick, the joining flanges being 1½ in. thick, and the bolts for connecting the same 1½ in. diameter. The lower flanges of the spandrels are made to suit the curve of the upper flanges of the girders, and are fitted to them by means of strips and 1¼-in. square-necked bolts.

The span of the main girders of the side spans are 34 ft. and 20 ft. respectively, with a similar rise of 8 ft. 9 in., and section of I form, 1 ft. 9 in. deep throughout; the upper and lower flanges being each 12 in. wide for both spans, and 1⅛ in. and 1½ in. thick respectively, with webs 1 in. thick at top and 1¼ in. thick at bottom. The face girders of the side spans are 34 ft. and 20 ft. respectively, with 7 ft. 9 in. rise, and are thus] in section, 2 ft. 9 in. deep throughout; the upper and lower flanges are 12 in. and 15 in. wide and 1⅛ and 1½ in. thick respectively, the lower outer edge having a raised molding.

As regards the materials used in the structure, the cement employed is the best Portland, finely ground, and with a minimum tensile strength of not less than 350 lbs. per square inch after seven days' immersion in water, the briquettes having been previously allowed to set for not more than 16 hours after gauging. The weight per striked bushel is specified at 112 lbs., with a residue of not more than 15 per cent. after passing through a sieve of 2,500 holes per square inch. The concrete is composed of 1 part of Portland cement by measure, 2 parts of clean sharp river sand, and 3 parts of gravel or 2-in. broken whinstone; a special finer concrete in the lock arches being composed of 1 part of Portland cement to 3 parts of crushed granite sand. The mortar employed is mixed in the proportion of 1 part of Portland cement to 2 parts of clean sharp river sand. The outside elevations from cornice level of the piers, abutments, parapets, newels, and lamp towers are faced with gray granite fine-axed over the face, and presenting a handsome appearance. The red granite panels and columns are polished, and greatly enhance the appearance. The footings of the center and two side piers are 18 in. and 15 in. deep, and are built of stones from 3 ft. to 4 ft. long and from 2 ft. to 3 ft. broad, squared and pick-dressed. The abutment footings consist of one course of cement concrete 2 ft. thick, and one course of stones 12 in. deep, from 3 ft. to 4 ft. long by 2 ft. to 3 ft. broad, squared and pick-dressed. The ashlar is laid in cement mortar, no joint exceeding $\frac{1}{16}$ in. being permitted. All the coping is secured by small granite cubes set in cement. The facing of the wing walls above ground is chisel-dressed in face and rock-dressed up to level of parapet.

The platform of the bridge is covered with a layer ¾ in. thick of best British bitumen manufactured from pure coal tar pitch. The carriage-way is of granite, the stones having a uniform depth of 6½ in. by 4 in. thick, their length being not less than 9 in. and not more than 14 in. The stones, which are required to be properly squared and dressed, are bedded on mortar and run in with hot pitch, no sand by itself being permitted to be used for bedding them. The gutters and curb are of granite, the stones being 12 in. broad by 7 in., and rough-axed on the surface, lengths of 3 ft. to 4½ ft. being specified. The pavement is composed of best patent granolithic laid upon concrete.

The cast iron, which forms the main item in the superstructure, is specified to stand without fracture a load exceeding 29 cwt. at the center of a bar 1 in. thick, 2 in. deep, and placed upon supports 3 ft. apart. The bars are specified to be cast 42 in. long, and three such are required from each melting. The usual requirements as to perfect soundness, evenness, surface, uniform thickness, and freedom from flaws, such as slag, air-holes, blisters, wants, lumps, inequalities, and similar imperfections, are duly exacted.

The steelwork in the flooring, etc., is required to stand a tensile load of 26 tons per square inch without fracture, every plate or bar being stamped with the maker's brand, and all surfaces being smooth, free from blisters, cracks, or flaws of any kind. The rivets are of best mild Siemens steel, capable of sustaining a tensile stress of not less than 26 tons per square inch, one rivet in every 200 being tested.

The lamp standards are bronzed and tastefully picked out with gold, while the dog-tooth molding round the arches, the outer molding of the panels on the spandrels, the bosses projecting from cavetti, and the armorial shields and panels are also gilded with gold leaf.

NOTES ON COMBUSTION.

By C. Chomienne, Engineer.

(*Continued from page 447.*)

HEATING SURFACE.

The heating surface of a boiler is composed of two parts:

1. The direct heating surface, which transmits to the water the heat developed by the fire-box, either by radiation or by contact.

2. The indirect surface, which transmits the heat only by contact.

It is then evident that 1 sq. m. of direct heating surface will produce more steam than 1 sq. m. of indirect surface; the more so since the gases in contact with the indirect heating surface have already lost a part of the heat which they contained in leaving the fire-box, and that the transmission through the walls of the tubes is in proportion to the difference of temperature between the gas and the wall or surface.

Many experiments, confirmed by practice, show that the quantity of heat transmitted by a unit of surface decreases rapidly as the distance from the fire-box increases, and consequently the increase of indirect surface beyond a certain limit is useless and only serves to make the boiler more complicated.

On the other hand, we can decrease too much this indirect surface, because when the products of combustion escape at too high a temperature, the formation of steam will rapidly diminish. This temperature in the case of an ordinary chimney 25 to 30 m. in height should never pass 200° C.

Regnault has made up a table of the specific heats of certain gases contained in the products of combustion, and he has shown that the specific heat of these gases differs very little from that of air, which is 0.240. If, then, we admit that we burn 20 kgs. of air and 1 kg. of coal, and that the gases escape from the chimney at a temperature of 300° C. instead of 200° C., the loss in calorics will be

$$20 \times 0.24 \times 100 = 480 \textit{ calorics.}$$

If the heating power of this coal is 7,000 calorics, the loss will be represented by

Coal burned per square meter of grate, kilograms.	Heating surface per square meter of grate, in square meters.			Surface per kilogram of coal.	Quantities of Heat.						Useful result, per cent.
					Transmitted by 1 square meter of grate to the heating surfaces.			Utilized.			
	Direct.	Indirect.	Total.		Direct.	Indirect.	Total.	Per square meter of grate.	Per square meter of surface.	Per kilogram of fuel.	
EXTERNAL FIRE-BOX—COOLING OF GASES TO 250° C.											
50	3.00	25.39	28.39	0.568	108,135	149,765	257,900	245,900	8,661	4,918	61.4
75	3 00	31.71	34.71	0.453	141,625	245,225	386,850	368,850	10,626	4,918	61.4
100	3.00	37.69	40.69	0.407	169,392	346,408	515,800	491,800	12,086	4,918	61.4
INTERIOR FURNACE, CORNISH BOILER—COOLING OF GASES TO 250° C.											
50	1.50	31.33	32.83	0,656	93,846	200,604	294,450	282,450	8,598	5,649	70.6
75	1.50	38.50	40.00	0 433	124,183	317,492	441,675	423,675	10,592	5,649	70.6
100	1.50	45.22	46.72	0.467	150,405	438,495	588,900	564,900	12,091	5,649	70.6
INTERIOR FURNACE, LOCOMOTIVE TYPE OF BOILER. COOLING OF GASES TO 250° C.											
50	5.00	30.24	35.24	0.704	140,878	166,122	307.000	283,000	8,030	5,660	70.8
75	5.00	37.68	42.68	0.569	185,631	274,869	460,500	424,500	9,946	5,660	70.8
100	5.00	44.25	49 25	0.493	222,820	391,180	614,000	566,000	11,331	5,660	70.8
200	5.00	73.30	78.30	0.391	329,710	898,290	1,228,000	1,228,000	14,470	5,660	70.8
400	5.00	114.54	119.54	0.299	479,175	1,976,875	2,456,000	2,456,000	18,889	5,660	70.8

$$\frac{480}{7000} \times 100 = 6.85 \text{ per cent.}$$

We may remark that this loss is greater as the quantity of air used is greater; and as the figure of 20 kgs. can be considered almost a minimum, it follows that this loss will be almost always greater than the figure given above.

The ratio between the direct and indirect heating surfaces varies according to the type of boiler and according to the strength of draft. The more the latter is increased the more the indirect heating surface may be increased.

The accompanying table, given by M. Ser, shows the proportions generally adopted in the three types of boilers most commonly used. The results of this table are applicable to fire-boxes burning coal, the radiating power varying with different kinds of fuel. The importance of the direct heating surface decreases when the fuel has less radiating power. The small table below permits us to take account of its effect:

FUEL.	Calorific Power.	Radiated Heat.	Relative Radiating Power. Coke=1.
	Calorics.		
Coke of good quality..........	7,000	60 per cent.	1.000
Anthracite or dry coal.........	7,500	55 "	0.916
Soft coal, with long flame.....	6,600	50 "	0.833
Lignite, very dry.............	5,600	40 "	0.667
Peat, dried at 100° C..........	3,800	30 "	0.500
Wood, dried at 140° C..........	3.650	28 "	0.467
Wood with 25 per ct. of water..	2,900	25 "	0.417

In steam generators placed over heating furnaces in metallurgic establishments, the direct radiation of the furnace does not exist and the average production of steam to the square meter of heating surface is considerably diminished. In practice it is usual to give to such generators a heating surface almost equal to that which they would have if the whole quantity of fuel employed in the furnace was burned in them directly.

If we admit a duty of 65 per cent. for the boiler with ordinary fire-box, this same boiler placed on a heating furnace would not give more than three-fifths of the result obtained in the first case, so that the coefficient would not be more than

$$0.65 \times \tfrac{3}{5} = 0.39$$

—that is, about 40 per cent. of the theoretical efficiency.

PRODUCTION OF STEAM PER SQUARE METER PER HOUR.

In boilers fired externally the average production of steam per square meter of heating surface per hour should be from 10 to 15 kg. If below 10 kg. there is too great an extension of heating surface; if above 15 kg. there is a loss of heat by the gases—that is, through the chimney.

As to tubular boilers, without artificial draft, the production may vary from 15 to 20 kg., 18 kg. being a very fair normal production.

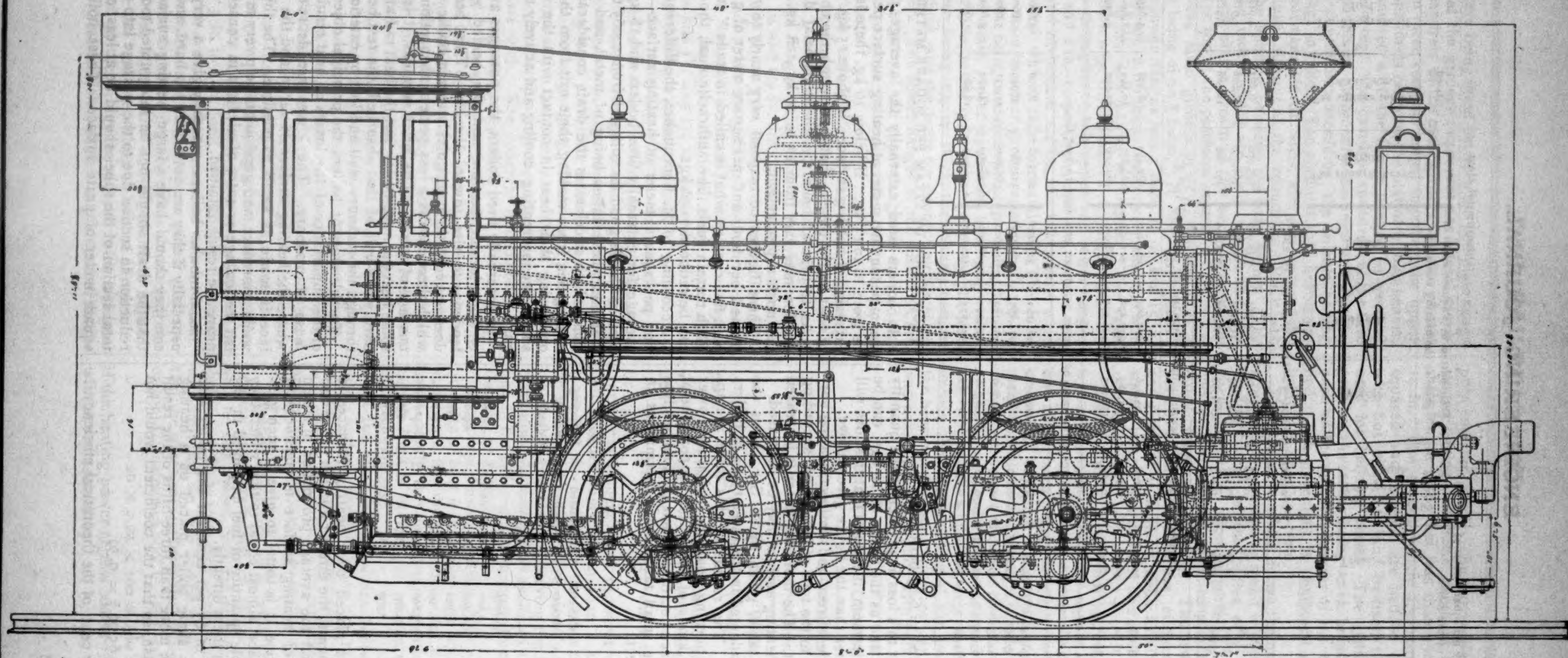
These figures correspond very nearly to 75 kg. of coal burned per hour and per square meter of grate; that is, with fine coal, or what is called in trade "run of mine." With certain fuels, like anthracite coal, the consumption can be reduced to 50 kgs.

According to M. Lencauchez, the difference of production per square meter of heating surface—13 kg. on an average for externally fired boilers and 18 kg. for tubular boilers—holds good for tubes of from 0.065 to 0.115 m. in diameter, these tubes being of metal, and of small section, which accelerates the draft considerably, and prevents gases from making their exit from the boiler without losing their heat in contact with the surfaces, the small size preventing cooling and actively mixing up the gas.

In externally fired boilers, the passages are necessarily of considerable section, and the heated gases have a tendency to rise toward the top. This, being of brick, does not cool them as quickly as a metallic surface, from which there results a less perfect absorption of heat and mixture of gases. The brick surfaces, it is true, radiate some heat upon the boiler, but the heat radiated represents hardly one-half of that absorbed, the rest being scattered through the masonry wall and lost by exterior cooling.

To this class of boilers the principal objection consists of the importance of the losses of heat resulting from the mass of masonry. The losses are decreased in cases where the heating surface is large and the masonry surface is made as small as possible. The thickness of the walls, moreover, and good joints help very much to diminish the leakage or entry of air, and in consequence to improve the result obtained.

Semi-tubular boilers generally give a very good result, especially if they are not driven too hard, and for that reason they should have a large heating surface. In order that the draft should not be interrupted too much by the reduction in section due to the passage into the tubes, the total section of the tubes should be at least 0.30 sq.m. per square meter of grate surface. These boilers give still



FOUR-WHEELED SWITCHING LOCOMOTIVE, BOSTON & ALBANY RAILROAD.

A. B. UNDERHILL, SUPERINTENDENT OF MOTIVE POWER.

better results when the passage of the gases into the tubes is not completed on the second course, but on the third, for then we do not have to fear the extinction of the flame or the separation of the combustible gases, which are produced when these gases enter the tubes at a very high temperature.

Masonry furnaces permit the use of coal of a poor quality, which could not be properly burned in a tubular boiler. In some cases externally fired boilers are found producing results almost as good as tubular boilers, and they certainly have the merit of simplicity in construction and comparative cheapness.

The tubular boiler with interior fire-box occupies much less space than an externally fired boiler, and for that reason alone it is often preferred. In every boiler of this class the combustion chamber should have sufficient size, since if it is too small the gases reach the tubes before they are completely burned, and the combustion is there stopped. The tubular boiler also permits the use of higher pressures than can be obtained with a plain cylinder boiler, because to resist such pressures the plates must be made so thick as to obstruct the passage of the heat.

TUBULOUS BOILERS.

In cases which are often presented, a boiler carrying a great volume of water is not the best for high production of steam. Thus, if in a cylinder boiler we increase the production of steam from 20 to 40 per cent., the efficient result is decreased from 5 to 10 per cent., while in tubular boilers the production of steam is increased with difficulty, and the efficiency at once falls from 10 to 20 per cent. As soon as we attempt to make one of these boilers produce more than 15 kgs. of steam per square meter of heating surface, the efficiency diminishes. Their only advantage is to permit the use of pressures as high as 200 lbs. without danger. The collapse of a tube will extinguish the fire at once. The problem of the production of steam at a very high pressure cannot, in fact, be solved in a practical way by the use of externally fired boilers, nor of boilers with interior fire-box, nor even with semi-tubular boilers, because their large dimensions require very thick plates in order to resist the force of the steam. These heavy plates cause a great increase of weight, and at the same time make the transmission of heat through them more difficult and the boiler less economical, without considering the fact that they increase the strains resulting from the inequality of temperature of different parts of the boiler, which tends to crack the plates and increase the danger of explosion. Finally the consequence of these accidents would be especially disastrous, since the destruction caused by a boiler which explodes is proportional to the quantity of water which it contains, and increases with its temperature.

In tubulous boilers, as they are sometimes called, or boilers composed of small elements, the tubes have a diameter varying from 0.07 m. to 0.12 m.; they can carry, in spite of their small thickness, very high pressures, and thus secure better transmission of heat through the metal; finally—and this is an essential point—the volume of water enclosed is very much less for an equal surface, so that the dangers of explosions are very much reduced.

The security which such boilers offer results not only from their small capacity, but from the subdivision of the water and the steam among a large number of tubes which communicate with each other only by narrow passages. In this way, if there is an explosion, the difficulty of communication between the different parts of the boiler prevents that instantaneous explosion, which is so terrible in the case of a large boiler. The whole thing is simply an escape of water and steam; one might almost say a simple leakage, of greater or less size, the steam escaping by the chimney, and the water into the fire-box.

Statistics have shown that boilers of this kind are, it is true, exposed to more frequent collapse of tubes, but this does not cause considerable damage. They compose a class of explosions of a special nature, the effects of which may be dangerous to the persons employed close to the boiler, but quite harmless for those at a short distance away only, or in other parts of the shop.

The doors giving access to the tubes should be kept carefully closed, and also the fire-box doors, as in case of the giving way of a tube, there will be much less danger.

In some of these boilers, in order to make their work more regular, the proportions of the reservoirs of water or of the steam drums are increased; but when this is done the danger of an explosion is also increased.

From the point of view of the steaming capacity per unit of heating surface, we should not require a tubulous boiler to produce more steam in proportion than is required from others.

The tendency to use these boilers composed of small elements and called "safety boilers," such as the Belleville, the Roser, the Terne & De Harbe, the Montupet, the Collet, the Babcock & Wilcox, the Ward, the Cowles, etc., is at present very marked. It is due probably to the increasing use of compound and triple-expansion engines, and also to the special conditions required in the application of electricity in cities, where space is limited, and where an explosion would have severe consequences.

I may say, however, in a general way, that they ought not to be used where the pressure required is not over 90 lbs., or where there are great variations in the supply of steam required, as the maintenance of the pressure and of the water level becomes very difficult in such cases. We are then obliged to have recourse to automatic apparatus to regulate the feed, and also to apparatus of some kind to regulate the pressure by acting upon the draft, as is very frequently done with Belleville boilers.

It may also be said that these boilers require very good water on account of the difficulty of cleaning them.

(TO BE CONTINUED.)

A FOUR-WHEEL SWITCHING LOCOMOTIVE.

THE accompanying engraving is from a working drawing of a four-wheeled switching locomotive of very neat design, built in the shops of the Boston & Albany Railroad for use on that road, under the supervision of Mr. A. B. Underhill, Superintendent of Motive Power.

The general design of the engine is well shown in the drawings, and presents no special features. The entire weight is carried on the four driving-wheels; as the engine weighs 66,000 lbs. ready for service, the average load per wheel is 16,500 lbs. The wheels are 52 in. in diameter, and are 8 ft. apart between centers. From the center of main driver to rear end of frame is 9 ft. 6 in.; from center of forward driver to front end of frame, 7 ft. 1 in., making the total length of the frames 24 ft. 7 in.

The boiler is 46 in. diameter of barrel; the shell is of Otis steel, ⅜ in. thick. There are 121 tubes, 2 in. outside diameter and 11 ft. 11⅝ in. long. The fire-box is of steel, and has a rocking grate. The boiler is built for a working pressure of 130 lbs. The center of the boiler is 5 ft. 9 in. above the top of the rail; the total height, from top of rail to top of smoke-stack, is 12 ft. 8¾ in. The boiler is of the straight-top pattern, and the steam-dome is near the center of its length.

The cylinders are 16 in. in diameter and 24 in. stroke. The cross-head and guides are of the pattern shown in the drawing. The main rod is 8 ft. 1 in. long between centers. The valve gear is of the ordinary shifting link type.

The engine is provided with air-pumps and driver-brakes. There are two sand-boxes, as needed in an engine of this class. The front draw-head is a heavy casting, bolted to the bumper-beam and braced to the cylinder saddle by a heavy tie-rod.

The engine has no tanks, the water and fuel being carried on a separate tender.

THE UNITED STATES NAVY.

SOME remarkable results have been recently secured by the Ordnance Bureau with the 4-in. rapid-fire gun provided with the Dashiell breech mechanism. At a trial at the proving-ground at Indian Head, on the Potomac, the gun was tested with the service charge of brown powder,

firing in salvos of five rounds. The first five were fired in 26 seconds, the second in 22 seconds, and the third in 17 seconds.

The 10-in. guns for the coast-defense ship *Monterey* have been tested, with very satisfactory results.

It is understood that the Navy Department has decided to make the 6-pdr. Hotchkiss gun the leading gun in secondary batteries. The reason for this is that, while the 6-pdr. throws a heavier projectile and has a greater range, it can be handled and worked almost as easily as the 3-pdr. gun.

ELECTRIC SIGNAL APPARATUS.

A new electric apparatus for directing the movements of a ship from the conning-tower is now under consideration by the Navy Department. It was submitted by Lieutenant Bradley A. Fiske, the inventor of the range-finder, and its object is to supply perfect automatic means of communication; it has so far succeeded as to bring battery, helm, and engine much more completely under the control of a single person than has heretofore been accomplished.

The new system includes numerous arrangements of apparatus. There are placed in the fighting-tower two arcs of conducting material, over which moves two pivoted arms. The arcs are graduated on each side of their central points to indicate revolutions of the propeller of the vessel. The arcs and arms are connected in series with two indicating instruments, one arc and one indicating instrument being located either on the bridge or in the fighting tower, the other one in the engine-room.

In connection with the needle of the instrument of the engine-room indicator are arranged two local circuits, each containing a bell or other suitable alarm. These circuits are respectively closed as the needle moves to its stops in one direction or the other.

If, for instance, it is desired to send a signal to the engineer to "go ahead," the arm of the arc in the fighting tower is moved to the right, and by this means the resistance in the circuit is diminished, causing a deflection of the needles of the two indicators in the same direction. The engineer then not only sees the needle of his indicator move, but also hears a bell sound. As this bell may be of different tone from the one included in the other local circuit, he has both visible and audible notice of the order.

Meanwhile, the person sending the order notes by the deflection of his indicating instrument that it has been transmitted. Numbers in the arc denote the order to be obeyed.

The steering of the ship is effected by a similar arrangement working on a steam-steering engine controlling the helm.

THE VICTORIA TORPEDO.

This torpedo has attracted much attention, and the accompanying illustration and description are taken from the latest report of the Naval Intelligence Office. It is understood that it is soon to have a very thorough test.

The coast-defense type of this torpedo is similar in form to the auto-mobile torpedoes now in general use, and is divided up into six compartments, as shown in fig. 1. The forward compartment contains the explosive charge, which is compactly stowed in the lower part, the upper part being divided into five compartments, four vacant and intended to contain water, the fifth, *D*, containing Holmes' light composition. Attached to the forward bulkhead of the air-chamber is a diaphragm, *B*, so connected to the piston-rod of a piston-valve, *C*, moving vertically in the cylinder *A* as to cause the piston to gradually descend in its cylinder as the air pressure decreases in the compressed-air chamber, allowing water to flow in through the thus opened top of the cylinder *A* to successively fill each of the four compartments mentioned above, in this manner adding weight forward to compensate for the loss of the expended air.

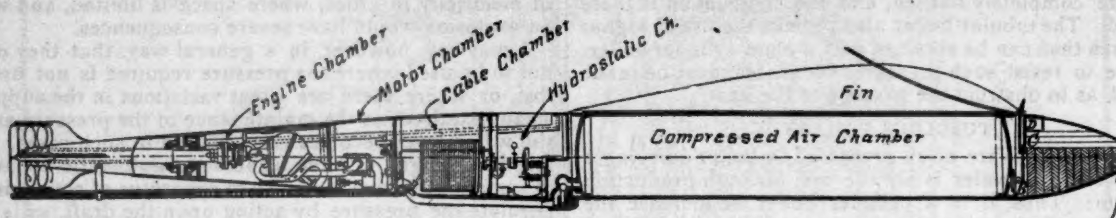


FIG 1

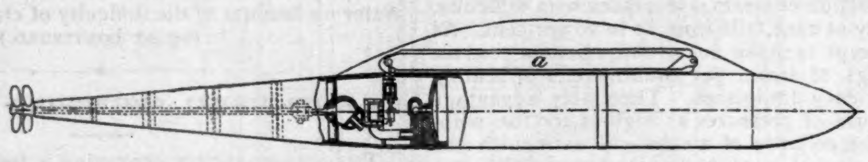


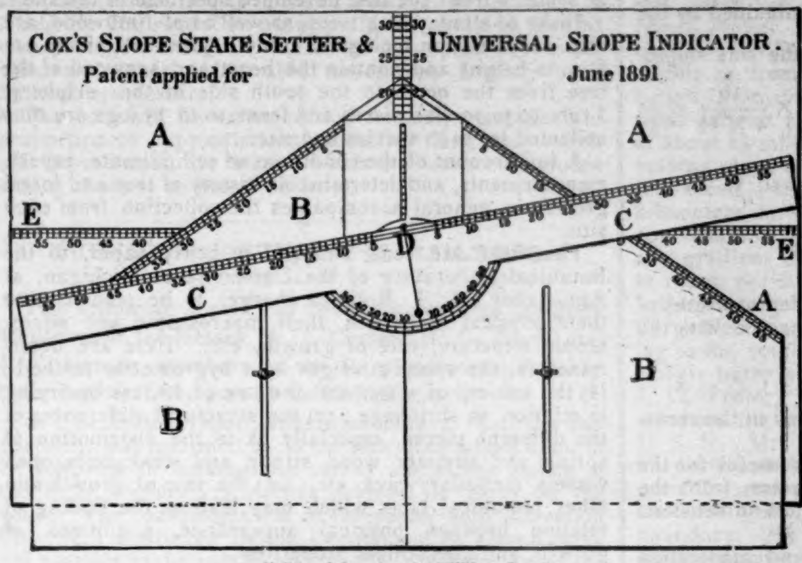
FIG. 2

THE "VICTORIA" TORPEDO.

The compressed-air chamber is connected with the engine by means of an admission-pipe as shown, this pipe being fitted with a valve operated by one of three motors in the motor chamber. To the rear of the compressed-air chamber is that for the hydrostatic valve, which, with its pendulum and servo-motor, actuates a horizontal rudder to keep the torpedo at a set depth when running. In the rear of this is the electrical cable chamber. The torpedo is controlled from the firing station on shore through the medium of a flexible gutta-percha cable of a specific gravity not varying much from that of sea-water, of which about 3,600 ft. are coiled in this chamber, the remainder being coiled up at the firing station ready for unreeling. This cable contains three sets of separately insulated copper wires, by means of which the power necessary for controlling, steering, raising to the surface and firing the torpedo is transmitted from suitable electrical batteries at the firing station to three magneto-electric motors placed in the next chamber to the rear. Of these motors the forward one is used to actuate the spindle of the compressed-air valve and regulate the admission of compressed air to the spherical air engine in the after chamber. The second motor has two functions. With a direct current it acts along a rod connecting it to a fuse in the nose of the torpedo to fire the charge (unless caught in a net or boom protection the fuse is intended to act by percussion), but with a reverse current it will serve to actuate, by means of a rod and gearing, a horizontal rudder to bring the torpedo to the surface of the water. The rear motor serves to actuate the vertical steering rudders.

When the torpedo is first discharged the cable will be paid out from shore, that reeled up in the torpedo being held by a grip, which at any time, by means of a cord and spring, can be released by opening the air-valve to its full limit, thus permitting cable to be paid out from the torpedo. The fin is shown in the figure, and this torpedo can be used with or without a float. The two propellers are right and left-handed, similar to those of the White-

head. Mr. Murphy's intention is to so arrange this torpedo that it can also be launched from fixed under-water positions in harbor, a mile or more from shore. For this purpose the torpedo, with an accompanying buoy, is held by four locked arms in a cage moored at the bottom. The buoy contains a coil of electric cable, and the cage is connected with the firing station on shore by a cable containing five strands of copper wire, three of them for the operations described above ; a fourth to cause the setting free of the torpedo and buoy, and the fifth, which is connected with electric cells, to cause the ringing of a bell at the firing station in case of accident to the torpedo or its cable. To operate the torpedo from such a position, it is



" Copyright, 1891, by William Cox."

Fig. 1.

released from its cage and then started off, pulling cable out of its buoy instead of from the shore, as in the case given above.

Mr. Murphy has also designed the naval torpedo shown in fig. 2, in which, instead of the hydrostatic valve used in the shore torpedo, he will use a dorsal fin, in which will be secured a float, *a*, which, through a dash-pot and servo-motor, will operate a side fin to keep the torpedo about 2 ft. under water.

A NEW SLOPE STAKE SETTER AND SLOPE INDICATOR.

THE accompanying illustration shows a new contrivance invented by Mr. William Cox, and made by the Keuffel & Esser Company, of New York, which must be of great use to engineers. For the engravings and description we are indebted to *The Compass*.

This device serves two special purposes :

1. By its means the exact point of intersection of the slope of an embankment or cutting with the natural surface of the ground, and consequently the position of the slope stakes, is immediately and accurately ascertained, and that without any calculations whatever.

2. The instrument gives instantly and also without any calculation all the various dimensions of embankments or cuttings, with varying ground surfaces and side slope ratios, from which the area of the cross-section may be calculated in the simplest manner possible and in the shortest time.

The indicator consists of three flat pieces of wood, metal, Bristol board, or other material—namely : *A A* the foundation plate with a central horizontal line and a central vertical line, both graduated to a convenient scale of feet. The point of intersection of these two lines represents the center line along the natural surface of the ground, while the center height is measured upward from the same on the vertical line. *B B* a vertical sliding-piece representing the cross-section of an embankment or cutting. This piece is interchangeable, so that it may suit different slope ratios and widths of road-bed. The slopes are graduated to the same scale of feet, as is also a vertical line drawn downward on each side of the road-bed, giving the height of each of its sides above the ground surface. *C C* a straight scale revolving upon the point *D* and representing the varying degrees of slope of the natural surface of the ground. This straight scale, which is graduated to feet right and left from its center, has fixed to its lower edge a semi-circular protractor, by means of which it may be set to any angle of slope.

These three pieces are kept in their respective positions by means of three small flat-headed screws with thumb-nuts, the middle one *D* acting as a pivot upon which the straight scale *C C* can be turned round. In the sliding section *B B* are three slots, through which the screws pass, so that a vertical movement up or down can be given to this piece.

To use the indicator, the sliding section is raised to the required center height, and the straight scale turned to the angle of slope of the surface of the ground ; the point of intersection of each of the side slopes with the surface of the ground is then at once seen, and their respective distances from the center line easily read off, thus fixing without estimation or trial the exact position of the slope stakes. The length of each of the side slopes can also be at once ascertained if required. Thus in fig. 2 the road-bed *a b* is assumed to be 18 ft. wide, and the height of the center line above the surface of the ground, or *d e*, is taken as being 12 ft., while the side slopes *A a* and *B b* are 1½ to 1, and the angle of the surface of the ground with the horizon is 10°. After setting the sliding-piece *B B* to 12 ft. and turning the protractor to 10°, we at once see that *A e* measures 37.2 ft. and *B e* = 21.6 ft. These distances then measured out from *e* are the positions of the slope stakes.

When the surface of the ground presents a different slope on each side of the center line, the straight scale must be set first to one slope and the distance read off, and then to the other slope and its corresponding distance noted.

We have said that this instrument serves also to ascertain in a very simple manner the cross-sectional area of an embankment or cutting. This may be done very quickly in the following way :

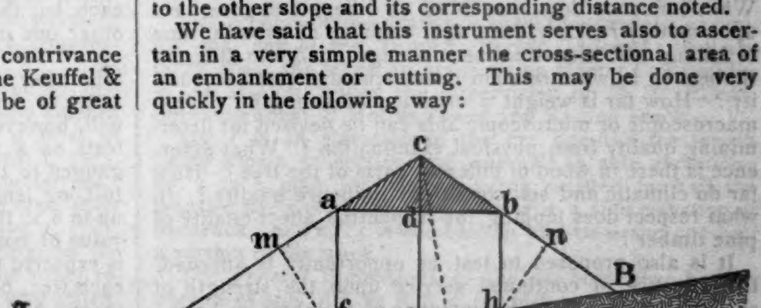


Fig. 2.

The side slopes of the sliding section *B B* are prolonged upward until they meet, as shown at *c* in fig. 2, thus forming with the ground surface line a triangle *A B c*. A graduated square, which slides along the straight scale (kept in position by a slot, through which passes the pivot *D*) enables the length of the perpendicular *C c* to be

immediately noted. This distance, as shown in fig. 2, is found to measure 17.8 ft. We then proceed as follows :

$$\begin{aligned} A\,e, \text{ already ascertained } &= 37.2 \\ B\,e \quad \text{"} \qquad \text{"} &= 21.6 \\ \text{whence } A\,B \; - &= 58.8 \text{ ft.} \\ \text{Half of } C\,c\left(\frac{17.8}{2}\right) \; - \; - &= 8.9 \text{ "} \\ \text{Their product} &= 523.32 \text{ sq. ft.} \end{aligned}$$

which is consequently the area of the triangle $A\ B\ c$. From this we now deduct the area of the small triangle $a\ b\ c$, which is a constant for all road-beds of the same width with the same side slopes, and is obtained by the formula $a\ b \times \frac{a\ b}{4r}$, where r is the ratio of the side slopes. In the present example this constant is $18 \times \frac{18}{4 \times 1\frac{1}{2}} = 54$ sq. ft., so that we have

$$\begin{aligned} \text{Area of triangle } A\,B\,c &= 523.32 \text{ sq. ft.} \\ \text{Less} \quad \text{"} \quad \text{"} \quad \text{"} \quad a\,b\,c &= 54.00 \text{ "} \\ \text{Leaves} \quad &469.32 \text{ "} \end{aligned}$$

as the area of the cross-section $A\ a\ b\ B$.

A list of constants, K, is furnished for different widths of road-beds and various slope ratios, to be used with the formula applying to the indicator—namely :

Cross-sectional area $A\ a\ b\ B = (A\ B \times \frac{1}{2}\ C\ c) - K$,

by means of which any area may be obtained in the shortest space of time possible.

This instrument will be found specially useful for the purpose of making out preliminary estimates, from the facility and accuracy with which the various dimensions and areas may be obtained.

This machine has been copyrighted and application made for a patent.

THE GOVERNMENT TIMBER TESTS.

An interesting circular has been issued by Mr. B. E. Fernow, Chief of the Forestry Division of the Department of Agriculture, in relation to the tests of timber undertaken by the Department. The object of these is to determine the properties of different kinds of timber and of timber grown in different parts of the country by a large number of tests on material of known origin. The points to be determined are formulated as follows :

"What are the essential working properties of our various woods and by what circumstances are they influenced ? What influence does seasoning of different degree have upon quality ? How does age, rapidity of growth, time of felling, and after-treatment change quality in different timbers ? In what relation does structure stand to quality ? How far is weight a criterion of strength ? What macroscopic or microscopic aids can be devised for determining quality from physical examination ? What difference is there in wood of different parts of the tree ? How far do climatic and soil conditions influence quality ? In what respect does tapping for turpentine affect quality of pine timber ?"

It is also proposed to test, as opportunity is afforded, the influence of continued service upon the strength of structural material, as for instance of members in bridge construction of known length of service. This series of tests will give more definite information for the use of inspectors of structures.

Besides these problems, many others will arise and be solved as the work progresses, and altogether a wealth of new knowledge regarding one of our most useful materials must result. It is proposed to publish results from time to time.

ORGANIZATION AND METHODS.

There are four departments necessary to carry on the work as at present organized—namely :

I. The collecting department.

II. The department of mechanical tests.

III. The department of physical and microscopic examination of the test material.

IV. The department of compilation and final discussion of results.

The collection of the test material is done by experts (Dr. Charles Mohr, of Mobile, Ala., for Southern timbers). The trees of each species are taken from a number of localities of different soil and climatic conditions. From each site five trees of each species are cut up into logs and disks, each piece being carefully marked, so as to indicate exactly its position in the tree ; four trees are chosen as representative of the average growth, the fifth or "check tree" the best developed specimen of the site.

Disks of a few young trees, as well as of limbwood, are also collected for biological study. The disk pieces are 8 in. in height and contain the heart and sapwood of the tree from the north to the south side of the periphery. From 50 to 70 disk pieces and from 10 to 15 logs are thus collected for each species and site.

A full account of the conditions of soil, climate, aspect, measurements, and determinable history of tree and forest growth in general accompanies the collection from each site.

The disks are sent, wrapped in heavy paper, to the Botanical Laboratory of the University of Michigan, at Ann Arbor (Mr. F. Roth, in charge), to be studied as to their physical properties, their macroscopic and microscopic structure, rate of growth, etc. Here are determined (*a*) the specific weight by a hygrometric method ; (*b*) the amount of water and the rate of its loss by drying in relation to shrinkage ; (*c*) the structural differences of the different pieces, especially as to the distribution of spring and summer wood, strong and weak cells, open vessels, medullary rays, etc.; (*d*) the rate of growth and other biological facts which may lead to the finding of relation between physical appearance, conditions of growth, and mechanical properties.

The material thus studied is preserved for further examinations and tests as may appear desirable, the history of each piece being fully known and recorded.

The logs are shipped to the St. Louis Test Laboratory in charge of Professor J. B. Johnson. They are stenciled off for sawing and each stick marked with dies, corresponding to sketch in the record, so as to be perfectly identified as to number of tree, and thereby its origin, and as to position in tree. After sawing to size, the test pieces are stacked to await the testing. One-half of every log will be tested green, the other half after thorough seasoning. A determination is made at the time of testing of the amount of water present in the test-piece, since this appears greatly to influence results.

From each tree there are cut two or three logs, from each log three or four sticks, two of standard size, the other one or two of larger size. Each standard stick is cut in two, and one end reserved for testing two years later after seasoning. The standard size for the sticks is 4 × 4 in. and 60 in. long for cross-breaking tests. There will, however, be made a special series of cross-breaking tests on a specially constructed beam-testing machine, gauged to the Watertown testing machine, in which the full log length is utilized with a cross-section of 6 × 12 up to 8 × 16 inches, in order to establish the comparative value of beam-tests to those on the small test-pieces. It is expected that, in the average, 50 tests will be made on each tree, besides 4 or 5 beam-tests, or 250 tests for each species and site. The methods adopted for the tests will be described more fully later.

All due caution will be exercised to perfect and insure the accuracy of methods and besides the records, which are made directly in ink into permanent books, avoiding mistakes in copying, a series of photographs, exhibiting the character of the rupture, will assist in the ultimate study of the material, which is also preserved.

The department of compilation and final discussion of results is as yet not organized.

CONCLUSION.

Such work as this, if done as indicated, and well done, will never need to be done over again. The results will

become the standard, the world over. The strength and value of a given species or even stick will then no longer be a matter of opinion, but a question of established fact, and we will learn not only to apply our timbers to the use to which they are best adapted, but also what conditions produce required qualities, thus directing the consumer of present supplies and the forest grower of the future.

The American Association for the Advancement of Science in its Section of Mechanics and Engineering has created an Advisory Board, to assist in securing improved methods, and the co-operation of other authorities will be welcomed to make this a truly national work.

So far the work has been confined to Southern Pines and Oaks (which, thanks to the courtesy of the Louisville & Nashville Railroad Company, could be obtained free of transportation charges); the scant appropriations available, and other unfavorable conditions, making such limitation necessary.

The work will be extended and its progress pushed in proportion to appropriations made by Congress, which will depend upon the interest which the work may arouse among those to be benefited by it.

THE INTERCONTINENTAL RAILROAD.

THE following report has been submitted to the State Department by Messrs. A. J. Cassatt, H. G. Davis, and R. C. Kerens, members of the Intercontinental Railway Commission on the part of the United States.

In a preceding report, submitted May 5, 1891, the Department was informed as to the line determined upon to be followed in making the survey and of the sailing of the three engineering parties selected to carry on the work. The consuls-general at Guayaquil and Guatemala City were instructed by the Department to extend every aid possible to the parties and to duly present them to the different Governments, by whom they were welcomed in the most cordial and hearty manner. The parties in Ecuador report that they were transported, with their baggage and equipments, from Guayaquil to Quito by that Government and at its own expense. The Government of Guatemala has also extended many favors and ordered some of their engineers to assist in making the survey through that Republic.

It is gratifying that the republics have welcomed and assisted so cordially the several surveying parties, as the enterprise is under mutual control and for the general benefit.

Some delay was occasioned, owing, in part, to inadequate communication and transportation, in the assembling of the delegates from the distant republics in Washington last winter; and delay has occurred in the payment of the money due from several of the republics, congressional action being necessary in each country.

The Congress of the United States appropriated $65,000 for the year ending June 30, 1891, and the same amount for the year ending June 30, 1892, making a total of $130,000. Of this amount there was on August 1, 1891, $56,910 remaining in the Treasury and available for use.

Chili has paid in $3,000 and Columbia $4,000, their quota to the common fund; so that on August 1, 1891, the Commission had about $64,000 for carrying on the work. We have information that some of the other republics are making arrangements to pay their proportion. The expenses are estimated at about $2,000 for each party per month and $1,000 for office and all other expenses, making about $7,000 for the total monthly outlay. It is therefore probable that it will be found expedient to ask of Congress a slightly larger appropriation for the next fiscal year. Your attention will be called to this matter in another communication previous to your transmitting to Congress your usual estimates.

The reports received from the different surveying parties have been very satisfactory.

Corps No. 1, Lieutenant M. M. Macomb, U. S. A., in charge, sailed from New York April 20, 1891, and arrived at Guatemala City May 9. The other officers of this party are Lieutenants Foote, Kennon, Rowan, Reber, Hedekin, U. S. A., and Mr. C. W. Haines, with Surgeon W. C. Shannon, U. S. A., as medical officer. The corps has since been augmented by the detail of four engineers whose services were tendered by the Government of Guatemala. Under date of July 29, 1891, Lieutenant Macomb reports that he is working toward the Mexican line, being encamped near Patulul. After completing the survey from Guatemala City to the Mexican line, he will return to Guatemala City and proceed southward with the survey through Central America.

Corps No. 2, in charge of Mr. William F. Shunk, sailed from New York April 10, 1891, and arrived at Guayaquil April 21, and at Quito May 7, 1891. The assistants in this party are Robert Burgess, William J. O'Connell, James Parker, Thomas F. Dempsey, D. M. Martinez, Jr., and Surgeon Frederick N. Ogden, U. S. N. Under date of July 12, from Ibarra, Ecuador, Mr. Shunk reports that he left Quito, June 3, and, although this is considered the most difficult part of the route, he had made an average of about 2¼ miles per day, and at the time of writing was making about 4 miles per day, with the hope of increasing that speed. He estimates the average cost of the first 100 kilometers, for grading, masonry, and bridges, at $20,000, equivalent to about $32,000 per mile, and he had not used any gradient exceeding 3 per cent., which is about equal to 150 ft. per mile.

Corps No. 3, in charge of J. Imbrie Miller, accompanied Corps No. 2 as far as Quito and then commenced surveying to the southward toward Peru. The other members of this party are William D. Kelley, Jr., W. L. Wilson, J. D. Foster, J. R. Kurtz (the latter sailed to join the party on the 10th of August), and Surgeon C. W. Rush, U. S. N. Mr. Miller reports, under date of July 14, that his party was then 100 miles south of Quito, and a cablegram informs us that he had reached Cuenca, 160 miles south of Quito, on August 1; this is near the Peruvian boundary. He expects to maintain a speed of 100 miles per month over the route.

The Commission adjourned to meet in Washington during the coming winter, by which time it is expected that the several engineering parties will have reported on a considerable part of the route, including the most difficult portion.

Judging from the satisfactory conference with the delegates from the other republics last winter in Washington, and the cordial manner in which the surveying parties have been received and assisted, we are encouraged to believe that the republics generally will welcome and give substantial aid and protection toward the construction of the contemplated railway.

TEXAS & PACIFIC STANDARD COAL CAR.

THE accompanying drawings show the standard 60,000-lbs. coal car of the Texas & Pacific Railroad; they are taken from the plans as prepared by Master Car-Builder W. D. Minton, under the supervision of M. W. Elliott, Superintendent of Motive Power and Rolling Stock.

Fig. 1 is an elevation of the car, one-half the length being shown in section and one-half in side elevation; fig. 2 is a plan, the flooring being omitted for half the length; fig. 3 is an end view; fig. 4 is a side elevation of the truck; and fig. 5 is one-half an end view and one-half a section of the truck.

The general dimensions of the car body are: Length outside of end sills, 34 ft. 8 in.; width outside of end sills, 8 ft. 9½ in.; distance from center to center of transoms, 25 ft.; distance from center to center of needle beams, 7 ft. The center sills are 9 in. apart; the first intermediate sills 3 ft. 2½ in. and the second intermediate sills 5 ft. 7½ in.

The longitudinal sills are 4¼ × 8 in. and 4¼ × 13 in., of yellow pine; the end sills 7 × 9 in., of white oak; the needle beams 5 × 9 in., of white oak, and the draft timbers 4½ × 8 in., of white oak. The coal sides are 40 in. in height above the platform, and are of yellow pine plank 2½ × 10 in., the side stakes being of 4¼ × 4½ in. white oak. The flooring is of pine 1¾ × 8 in., with ship-lapped joints.

The construction of the car body is well shown in the

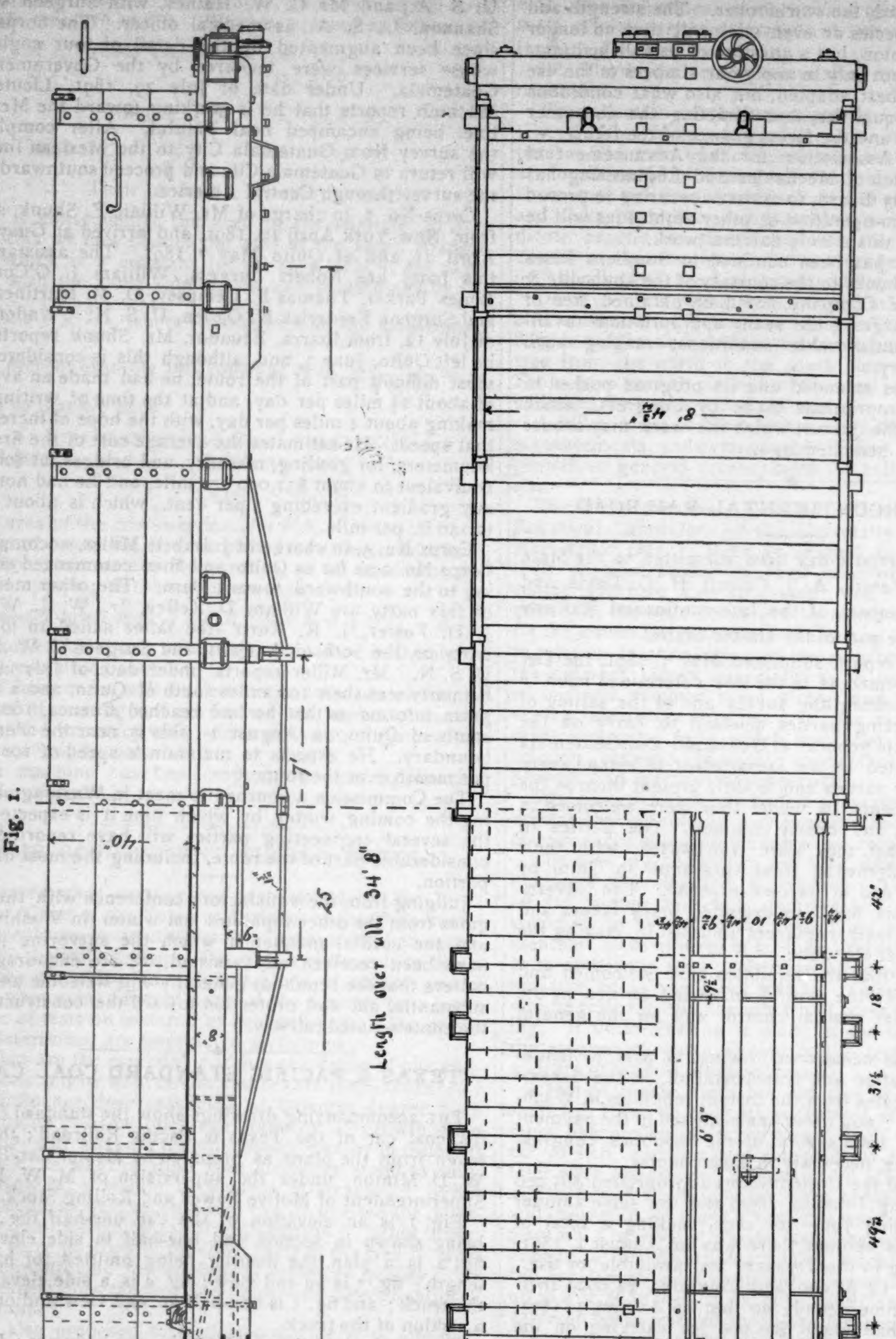


Fig. 1.

Fig. 2.

STANDARD COAL CAR, 60,000 LBS. CAPACITY, TEXAS & PACIFIC RAILWAY.

M. W. ELLIOTT, SUPERINTENDENT OF MOTIVE POWER AND ROLLING STOCK; W. D. MINTON, MASTER CAR BUILDER.

drawings. There are eight sills mortised and tenoned into the end sills, the latter being secured by four 1¼-in. truss rods. The long sills are further secured together by four ¾-in. cross rods. The body transoms are of 1 × 7-in.

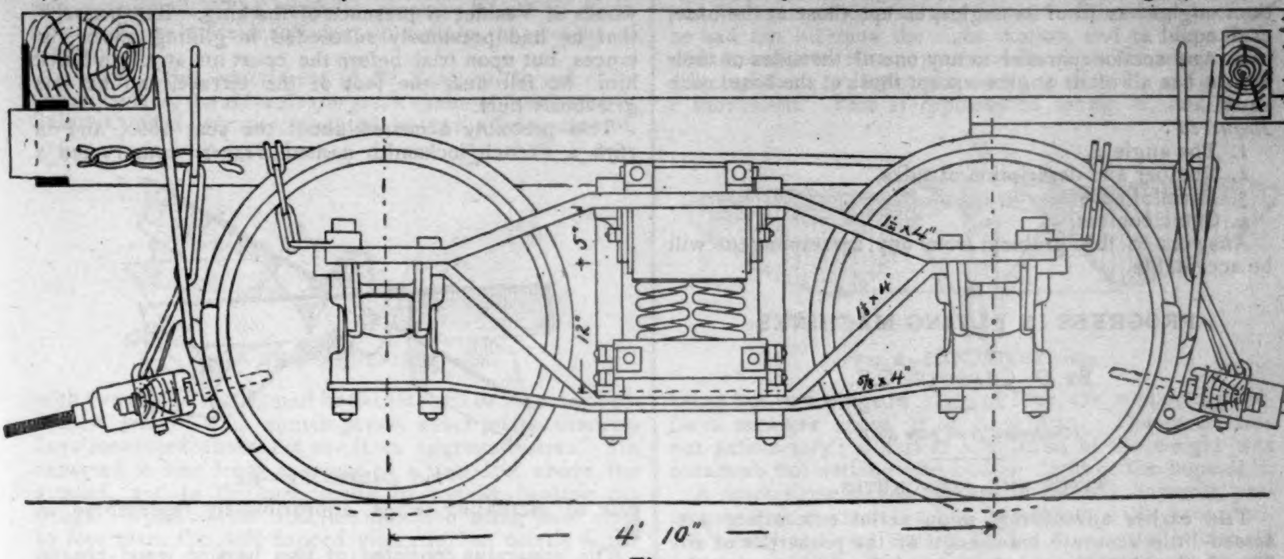


Fig. 4.

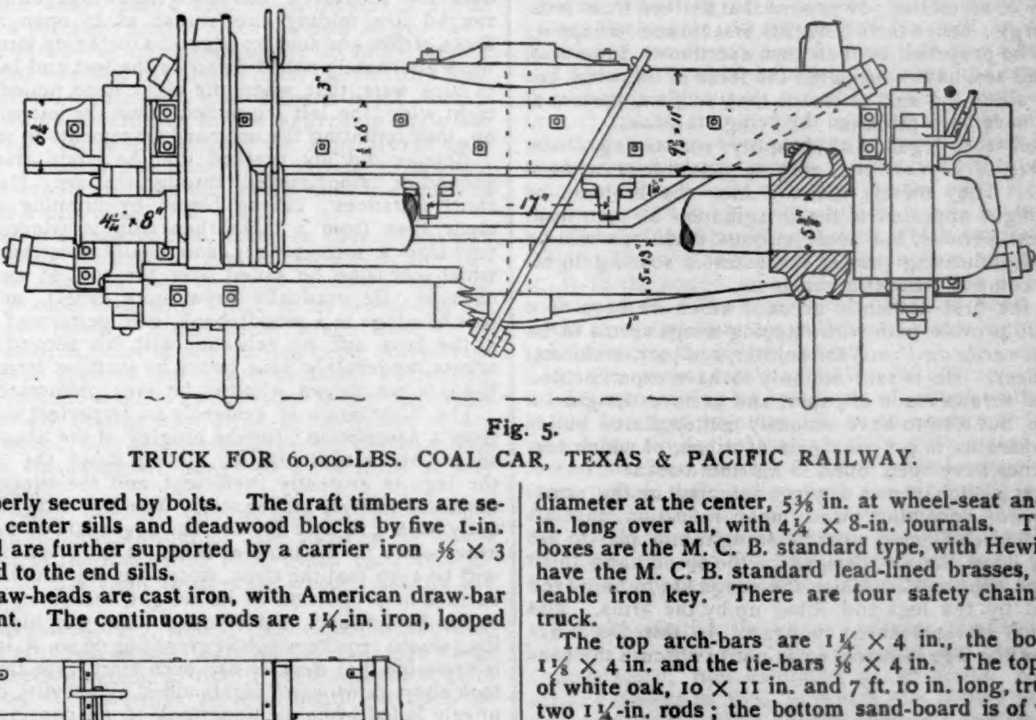


Fig. 5.

TRUCK FOR 60,000-LBS. COAL CAR, TEXAS & PACIFIC RAILWAY.

iron, properly secured by bolts. The draft timbers are secured to center sills and deadwood blocks by five 1-in. bolts, and are further supported by a carrier iron ⅝ × 3 in., bolted to the end sills.

The draw-heads are cast iron, with American draw-bar attachment. The continuous rods are 1¼-in. iron, looped

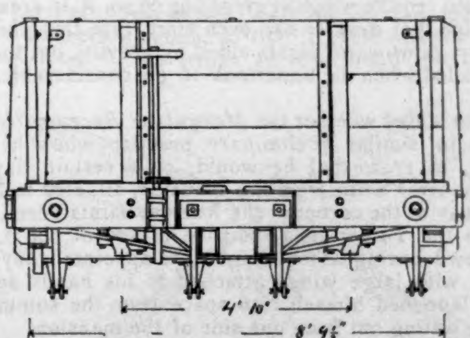


Fig. 3.

at the ends and secured by keys. The follower-plates are 1½ × 7 × 11 in., and the draw-springs are of steel, 6 × 6 in., two coil. The stake-pockets are of pressed steel. Steps, brake irons, etc., are of the usual pattern.

The trucks are of the rigid pattern, and are carried on four 33-in. double-plate cast-iron chilled wheels. The distance between centers of axles is 4 ft. 10 in.; between centers of arch-bars, 6 ft. 3 in.; between centers of springs, 6 ft. 3 in.; between centers of side-bearings, 4 ft. 10 in. The axles are of iron, of the M. C. B. standard pattern for 60,000-lbs. cars, being 4⅝ in. in diameter at the center, 5⅜ in. at wheel-seat and 7 ft. 0¼ in. long over all, with 4¼ × 8-in. journals. The journal boxes are the M. C. B. standard type, with Hewitt lid, and have the M. C. B. standard lead-lined brasses, with malleable iron key. There are four safety chains to each truck.

The top arch-bars are 1¼ × 4 in., the bottom bars 1⅛ × 4 in. and the tie-bars ⅞ × 4 in. The top bolster is of white oak, 10 × 11 in. and 7 ft. 10 in. long, trussed with two 1¼-in. rods; the bottom sand-board is of white oak, 5 × 13 in. and 7 ft. 10 in. long, and trussed with two 1-in. rods. Each truck has two four-group bolster springs, 7 in. high. The center-plate is of steel, of pattern shown in the drawings, and the king-bolt is 1¾ in. in diameter and 23 in. long. The threads on all bolts are of the U. S. standard pattern.

The brake-gear is of the usual pattern, as shown in the drawings, and the brake-beams are hung from the car body.

The St. Charles Company at St. Charles, Mo., is now building 300 cars for the road from these drawings.

A PROBLEM.

THE following has been submitted for solution by Mr. Aloha Vivarttas, of New York. It may be said that it has a practical application in designing.

Proposition.—A pyramid has the following properties;

1. The angle of each of the sides at the apex equals x.
2. A section on any plane in which lies the angle formed by two adjacent sides has the same angle x at the apex.
3. Any section perpendicular to any one of the sides or their angles has all of its angles, except those at the base, each equal x.
4. Any section parallel to any one of the sides or their angles has all of its angles, except those at the base, each equal x.

Required:

1. The angle x.
2. Number and description of sides.
3. Form of base.
4. Cubic content.

Answers to this problem from any correspondent will be acceptable.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page* 465.)

WINGS AND PARACHUTES.

The earlier adventurers upon aerial enterprises possessed little accurate knowledge of the properties of air. They had only their observations of the birds as a guide, and knew of no motive power save that derived from muscular energy; hence their thoughts first turned to flapping wings, to be propelled by their own exertions. Some few, as we shall see, have considered the force of the wind, but it is only since the age of steam that artificial motors of any kind have been proposed for flying machines.

The well-worn legends of antiquity, concerning *Dedalus*, *Abaris*, *Archytas*, etc., may be passed over without comment. They merely indicate how the problem of artificial flight appealed to the imagination of men from the earliest periods, but some curious traditions will be mentioned, indicating partial successes in soaring flight, when we come to treat of aeroplanes.

About the first authentic account which we have of a proposal to provide man with flapping wings seems to be due to *Leonardo da Vinci*, the painter, sculptor, architect, and engineer. He is said not only to have experimented with aerial screws made of paper, and to have designed a parachute, but also to have seriously contemplated building an apparatus to propel a pair of wings, of which several sketches have been found in his note-books.

The first sketch shows a wing, actuated by the arms, but *Da Vinci*, becoming aware, upon reflection, that all possible muscles of man must be brought into play to act effectually upon the air, designs in the second and third sketches an apparatus in which the wings are to be waved downward by the legs and lifted up by the arms. The third sketch is represented in fig. 2. In this *Da Vinci* only shows the legs in place, so as not to obscure the con-

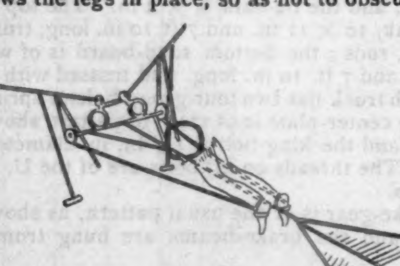


Fig. 2.—LEONARDO DA VINCI—1500.

struction of the parts. The date is probably about the year 1500. The construction is simple, and might not prove altogether inefficient did the muscles of man possess the same energy and rapidity of action as do those of birds in proportion to their respective weights. It is not known just how far *Da Vinci* elaborated his idea, but he never put it to practical test, and it is chiefly mentioned here as a curious forerunner of actual experiments.

The first wing experiment reported by tradition seems to be that of a French tight-rope dancer named *Allard*, who, under the reign of Louis XIV., announced that he would fly from the terrace at Saint Germain toward the woods of Vesinet in presence of the king. It is probable that he had previously succeeded in gliding short distances, but upon trial before the court his strength failed him; he fell near the foot of the terrace, and he was grievously hurt.

This probably occurred about the year 1660, and in 1678 a French locksmith named *Besnier* constructed a

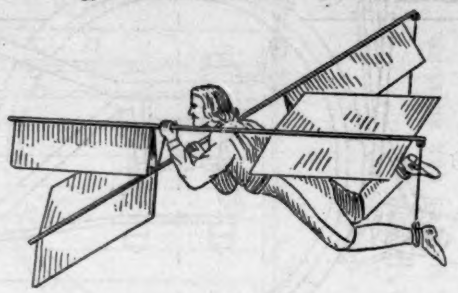


Fig. 3.—BESNIER—1678.

pair of oscillating wings, approximately represented in fig. 3.

The apparatus consisted of two bars of wood hinged over the shoulders, and carrying wings of muslin, arranged like folding shutters, so as to open flat on the down stroke and fold up edgewise on the up stroke. They were alternately pulled down by the feet and by the arms, in such wise, that when the right hand pulled down the right wing, the left leg pulled down the left wing, and so on, thus imitating the ordinary movements in walking.

Besnier did not pretend that he could rise from the ground or fly horizontally through the air. He only tried short distances; having begun by jumping off from a chair, then from a table, then from a window-sill, and next from a second story, and finally from the garret, on which occasion he sailed over the roof of an adjoining cottage. He gradually grew more expert, sold his first pair of wings to a mountebank, who performed with them at the fairs, and he expected with his second pair to fly across moderately wide rivers by starting from a height, but it is not known whether he ever performed this feat.

The illustration is evidently an imperfect sketch made from a description; for the hinging at the shoulder is not shown, the attachment for pulling down the wings with the legs is evidently inefficient, and the supporting surfaces are entirely inadequate. The four wings are apparently each 3 ft. by 2 ft; say, an aggregate of 24 sq. ft. in area, while in the table of birds, to be given hereafter, it will be seen that the duck, which has the smallest bearing surface in proportion to its weight, measures 0.44 sq. ft. to the pound, and at this rate a man, weighing, say, 150 lbs., would require wings aggregating 66 sq. ft. in area. It is probable that *Besnier* had even more than this, that he took short downward flights aided by gravity, but that he utterly failed when he undertook to go considerable distances.

It is not stated whether the *Marquis de Bacqueville* had engaged in similar preliminary practice when he announced, in 1742, that he would, on a certain day, fly across the river Seine from his mansion, situated in Paris on the quay at the corner of the Rue des Saints Pères, and alight in the Tuilleries, a distance of 500 or 600 ft. A large crowd having assembled on the appointed day, the marquis, with large wings attached to his hands and to his feet, launched himself into space from the summit of a terrace jutting out from one side of the mansion.

For a space he seemed to get along well, but soon his movements became uncertain, he faltered, and then he fell, alighting upon the deck of a washerwomen's barge a short distance out into the stream. He broke his leg in the fall, and never attempted the feat again.

The *Marquis de Bacqueville* was judicious in trying the experiment over a water-bed, for could he have held out but a few feet further he would probably have escaped with a mere ducking. He probably glided about 120 ft.

with most violent exertions, and fell when his strength became exhausted. Fig. 4, which is probably incorrect, represents the traditional apparatus with which this feat was attempted. The surfaces measure about 24 ft. in area, and are quite insufficient to sustain the weight of a man.

Aware of this experiment of *De Bacqueville* and of its consequences, the *Abbé Desforges*, a canon of the church at Sainte-Croix at Étampes, invented, in 1772, a flying chariot,

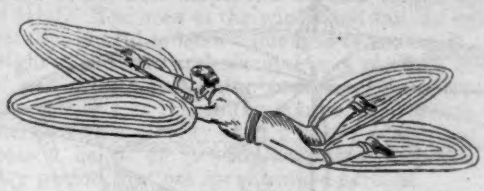


FIG. 4.—DE BACQUEVILLE—1742.

with two wings and a small horizontal sail or aeroplane attached, which from contemporary descriptions seem to have measured about 145 sq. ft. in aggregate area. He expected to rise from a height of a few feet above the ground, and to fly horizontally by rapidly beating his wings. Upon actual trial, the machine being held aloft by four men, the *Abbé* flapped violently, but utterly failed to start off. Indeed, some of the accounts say that the action of the wings pulled him down instead of up, so that he got a harmless tumble when the men let go.

In 1781, *Blanchard*, who subsequently became a fervent aeronaut, and who was the first to cross the British Channel in a balloon, constructed near Paris a flying chariot with four wings, measuring in the aggregate some 200 sq. ft. in area. He never exhibited the apparatus in public, having probably ascertained by private experiment that he was unable to move the wings rapidly enough to produce any useful effect.

These last two experiments, taken in connection with those previously mentioned, exhibit fairly well the two horns of the dilemma that confront inventors who endeavor to provide man with wings to be worked by his own muscular power. Either those wings have to be relatively small, in order to permit their being waved rapidly—and then they do not afford sufficient supporting area—or if they are made to approximate to the proportion which generally obtains with birds, or about one square foot to the pound, they become so large that the man does not possess the muscular power to wave them at any adequate speed.

Ideas, however, die hard, and we may disregard somewhat the chronological order of date, in order to follow the evolution of the small-wing idea, which each fresh inventor fancies has been incorrectly worked out by his predecessors.

Of these was *Bourcart*, who in 1866 experimented with the apparatus shown in fig. 5. It consisted of four wings with a feathering action, so that it presented the edge to the air upon the up stroke and the broad side upon the

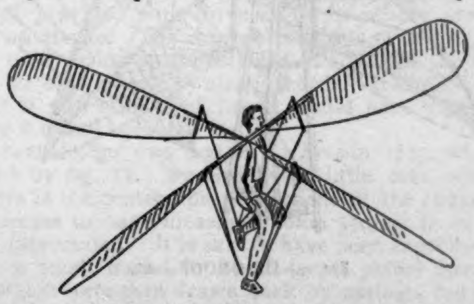


FIG. 5.—BOURCART—1866.

down stroke, but the results were insignificant, and the experiment was abandoned. The supporting areas measure approximately some 36 sq. ft., but are only effective upon the down stroke.

In 1873 Professor *Pettigrew* published his work on "Animal Locomotion," in which he called attention to the fact that birds in flapping flight, flex their wings so as to resemble a screw propeller, and that the tips describe a figure of 8 motion. This led to the inference that man had not succeeded in raising himself with wings because he had not hit upon the right motion, and in 1879 *Dandrieux* constructed an apparatus in which the wings were attached to an oblique axle, so as to describe a figure of 8 movement. This is represented in fig. 6, and there

FIG. 6.—DANDRIEUX—1879.

being but two wings in place of four, the supporting surfaces measure about 32 sq. ft. in area. The result was not satisfactory; a partial alleviation of the weight was obtained, but nothing like human flight or the hope of it.

A much more successful experiment had, however, previously been made at the first Exhibition of the Aeronautical Society of Great Britain, held at the Crystal Palace, in London, in 1868. Mr. *Charles Spencer* exhibited an apparatus consisting of a pair of wings measuring each 15 sq. ft. in area, to which was attached an aeroplane measuring 110 ft. more, and also a tail like a boy's dart, and a longitudinal keel-cloth to preserve the equilibrium, the whole weighing 24 lbs. and giving a sustaining surface of 140 sq. ft. As Mr. *Spencer* was an athlete, he was enabled, by taking a preliminary run down a little hill, to accomplish short horizontal flights of 120 to 130 ft., in which he was wholly sustained by the air. He weighed 140 lbs., and his apparatus, which, it will be noted from the description, differed from those which propose "wings for man" by the addition of an aeroplane, measured 0.85 sq. ft. to the pound, or about the proportion of the larger soaring birds. The experiments attracted great attention at the time, but were not sufficiently encouraging to warrant pursuing the matter further.

At the same exhibition Mr. *W. Gibson* showed a machine consisting of two pairs of wings, worked by the hands and feet together, so as to impart a feathering movement similar to that of birds. He stated that in a former machine, having only one pair of wings of lighter construction, their action upon the air during a vigorous down stroke was sufficient to raise the man and machine; but no practical demonstration was given, and although the inventor stated that he was then engaged in constructing a more perfect machine, nothing more has been heard of it.

Notwithstanding these many failures, the idea does not seem to be dead yet, for in September, 1890, Mr. *W. Quartermain*, who exhibited an explosion engine for aerial purposes in 1868, in which the motive power was derived from the gases generated from a species of rocket composition, wrote a letter to the London *Engineer*, in which he stated that he had abandoned his attempts to procure a light and energetic motor from hydrocarbonous matter, in favor of man's weight and muscular power, which he considers preferable, and was then engaged in experimenting with an apparatus consisting of four wings, formed after the stag beetle type, each 10½ ft. long by 2½ ft. wide, opposing 90 sq. ft. of expanse of surface to the air. This arrangement weighed 350 lbs., including 212 lbs. for the weight of the operator, who by working both handles and treadles, thus bringing all his muscles into action as well as his weight, was enabled to wave the wings, which are 25 ft. from tip to tip, so as to produce a double stroke for every single stroke of his body on the motive shaft. He describes the result as resembling that of domestic fowls flapping their wings without lifting themselves from the ground, but is of opinion that the uplifting force was greater than his weight of 212 lbs., and believes that further improvements in the mechanism, with more skilful workmanship, might produce an ascensive force greater

than the whole weight of 350 lbs. This may well be doubted, for not only will it be shown hereafter that the energy of man must be less than that of birds, but none of the latter fly with so small a bearing surface in proportion to the weight—0.26 square foot to the pound—as in *Quartermain's* apparatus.

It has been suggested, however, that umbrella-like surfaces might prove more effective than wings, and increase the uplift to be derived from the air. Such contrivances were experimented upon by *Sir George Cayley*, who constructed, about 1808, a pair of wings which appear from the drawings to have been a fabric stretched tightly over a dished frame, this framework consisting of two ribs at right angles to each other, bent and tied across so as to secure rigidity. This double umbrella contained 54 sq. ft. and weighed only 11 lbs., and the inventor says: "Although both these wings together did not compose more than half the surface necessary for the support of a man in the air, yet during their waft they lifted the weight of 9 stone" (126 lbs.). It is not stated with what speed they were wafted nor with what power, but that the result did not promise to provide "wings for man" may be inferred from the fact that *Sir George Cayley*, in a very valuable series of articles in *Nicholson's Journal* for 1809 and 1810, starts out with the assertion that, in order to accomplish aerial navigation, "it is only necessary to have a first mover which will generate more power in a given time, in proportion to its weight, than the animal system of muscles."

The next experiments with umbrella-like wings attracted attention all over Europe. They were carried on by *J. Degen*, a clockmaker of Vienna, from 1809 to 1812, with the apparatus shown in fig. 7. It consisted of two wings 8½ ft. wide and 22 ft. across in the aggregate, each being shaped somewhat like a poplar or an aspen leaf.

Fig. 7.—DEGEN—1812.

They were stretched upon an umbrella-like frame and thoroughly braced back, both above and below, to a central stick by a number of small cords. The supporting surfaces consisted of bands of taffeta so attached as to have a valvular action, in order to imitate the supposed action of the feathers of birds, and the total supporting surface was 130 sq. ft., while the weight, without the operator, was stated at 20 lbs.

With this apparatus *Degen* was stated, in 1809, to have risen to a height of 54 ft., by beating his wings rapidly, in presence of a numerous assembly in Vienna, and all the newspapers began to publish accounts of the performance.

These descriptions failed to mention one important addition. *Degen* was also attached to a small balloon capable of raising 90 lbs., so that the uplift exerted by the wings was only 70 lbs. of the 160 lbs. weight of the operator and his apparatus.

In 1812 *Degen* went to Paris to exhibit his invention. He then stated that the balloon was of no sort of utility in obtaining headway, but that it was necessary as a counterpoise to maintain his equilibrium and to lighten his muscular efforts. He evidently expected by the action of his wings to drag the balloon along in still air while it lifted part of his weight.

He gave three public exhibitions in Paris, but unfortunately for him, as there was wind upon each occasion, he was blown away, and on the third attempt he was attacked by the disappointed spectators, beaten unmercifully, and laughed at afterward as an impostor.

The umbrella idea had, however, previously proved to be of value for parachutes, and in 1852 *Letur* devised the apparatus shown in fig. 8, with which he expected to direct himself through the air, by means of the wings and tail, first starting from an elevation.

In 1854 he ascended from Cremorne Gardens in London, suspended about 80 ft. below a balloon manœuvred by Mr. Adam, the areonaut, who was assisted by a friend. *Letur* performed several evolutions in the air by means of his wings, none of them apparently very conclusive; but

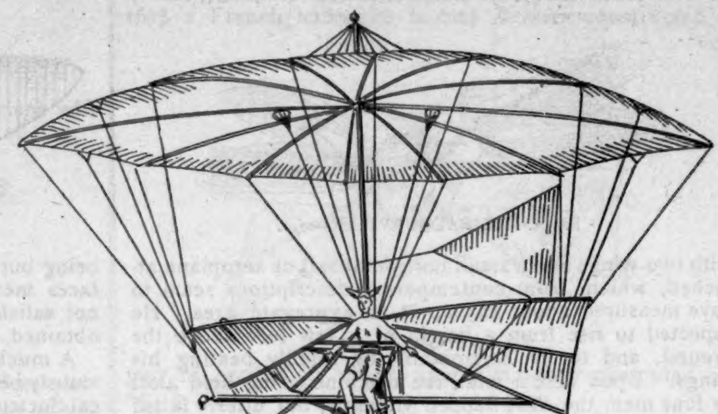


Fig. 8.—LETUR—1852.

in coming down near Tottenham, the wind carried the apparatus violently against some trees, and poor *Letur* received injuries which resulted in his death.

His apparatus measured about 660 sq. ft. in bearing surface, and had he been entirely detached from the balloon, it is possible that he might have reached the gound in safety; but it is evident that his wings would have been of little service in enabling him to obtain more than a slight horizontal direction.

Undeterred by this sad fate, a Belgian shoemaker named *De Groof* designed, in 1864, an apparatus which was a sort of cross between beating wings and a parachute. His plan was to cut loose with it from a balloon, and to glide down in a predetermined direction by manœuvring the supporting surfaces. He endeavored to make a practical experiment, both in Paris and in Brussels, but it was only in 1874 that he succeeded in doing so in London.

The apparatus is shown in fig. 9. It consisted of two wings, each 24 ft. long, moved by the arms and the

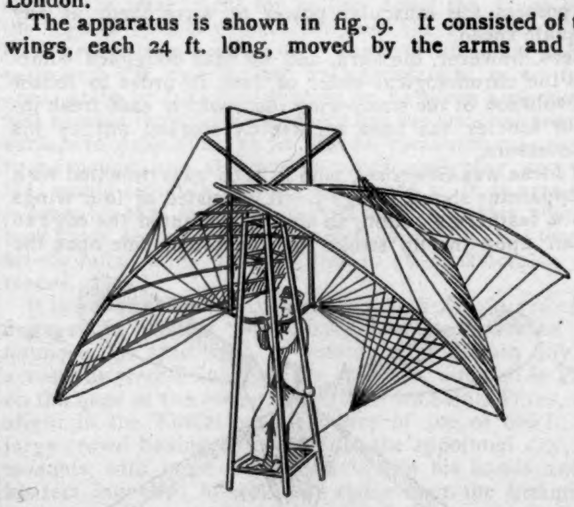


Fig. 9.—DE GROOF—1864.

weight of the operator, and of a tail 20 ft. long, which could be adjusted by the feet.

De Groof first went up on June 29, 1874, from Cremorne Gardens, London, attached to the balloon of Mr. Simmons. He came down safely, and claimed to have cut loose at a height of 1,000 ft., but it was subsequently stated by others that in point of fact he had not, upon this occasion, cut loose at all, but had descended still

attached to the balloon. In any event, he went up again on July 5 following, with the same aeronaut, and on this occasion he really did cut loose.

The result was disastrous. As soon as, in the descent, pressure gathered under the moving wings, they were seen to collapse together overhead and to assume a vertical position, when *De Groof* came down like a stone, and was killed on the spot.

Had the wings been prevented from folding quite back, by means of suitable stops, the descent might not have proved fatal. The area of the wings and tail, as extended horizontally, is said to have amounted to 220 sq. ft., while the weight of the man and machine was 350 lbs., or at the rate of 0.65 square foot to the pound. This corresponds to a pressure of 1.54 lbs. to the square foot, which would be generated by a velocity of 25.7 ft. per second, or a free fall from a height of 10.3 ft.; an unsafe distance for an ordinary person, but not for a trained acrobat.

Ordinary parachute practice is said to allow from 2 to 3 sq. ft. per pound, corresponding to velocities in falling of 14.7 to 12 ft. per second.

It was the most egregious folly for *Letur* and *De Groof*, as well as for *Cocking*, who was killed in 1836 in an experiment with a parachute shaped like an inverted umbrella, to attempt a descent with an apparatus previously untried to test its strength and behavior. A few prior experiments, with a bag of sand, instead of the man, would have exhibited the action that was to be expected.

Another class of inventors of "wings for man" have endeavored to secure safety by the use of large bearing surfaces. The first of these was probably, *Meerwein*, architect to the Prince of Wales, in 1784, who proposed an apparatus shaped like the longitudinal section of a spindle, separated into two wings, by a hinge at the center. It measured nearly 200 sq. ft. in area, and probably was never tried, but if it had been, it is quite certain that a man could never have imparted to the wings sufficient velocity to perform any useful effect.

The next proposal of this class was that of *Bréant*, who

FIG. 10.—BRÉANT—1854.

designed in 1854 the apparatus shown in fig. 10. It consisted of two wings, each measuring about 54 sq. ft. in area, and provided with three valves to relieve pressure on the up stroke. The down stroke was to be produced by the joint action of the feet and hands, and the wings were to be drawn back by elastic cords. It is not known whether it was ever tried, but it would have proved ineffective if it had been.

The next design was that of *Le Bris* in 1857, which is exhibited by fig. 11. By noting the little man working the levers in the center, the proportions of the apparatus, which seems to have measured some 550 sq. ft. in area, will be appreciated. It is said to have been experimented with in a small model, in which levers pulled down the wings which were then drawn back by springs, but it did not succeed in rising into the air, as was hoped by the inventor.

Before proceeding to describe other designs for winged machines, to be driven by artificial motors instead of muscular power, it may be well to call attention to the fact that not only has every attempt of man to raise himself on the air by his own muscular efforts proved a complete failure, but that there seems to be no hope that any amount of ingenuity or skill can enable him to accomplish this feat.

It has been argued that there is no proof that, weight for weight, a man is comparatively weaker than a bird, and that, inasmuch as he can raise his weight in walking up a stairway, he should be able to raise it by acting upon the air with a suitable apparatus. The weak point about

FIG. 11.—LE BRIS—1857.

this argument is not only that the weight and bulk of such an apparatus become a surcharge on the muscular power of the man, as would be, for instance, the case were an artificial pair of wings applied to an ostrich, but that among the birds themselves the power to rise vertically unaided does not exist for the larger species. These have to resort to various artifices, such as running against the wind or dropping from a perch, in order to gain that initial velocity which enables their surfaces to derive support from the air, and this probably furnishes a good reason why no flying birds exceed some 50 lbs. in weight; for small animals must possess more energy in proportion to their size than large ones.

Assuming that the speed of contraction in the muscles of two similar birds of different sizes is the same, it is evident that the work done per unit of time will be in ratio to the sectional area, or as the square of the dimensions, while the weight to be moved will vary as the cube of the dimensions; hence the rate of increase between the energy and the weight will be:

$$\sqrt[2]{\text{Energy}} \quad \text{varies as} \quad \sqrt[3]{\text{weight}},$$

or to put it in the shape of formulas which shall express the relative energy of animals of the same class:

$$E \propto \sqrt[\frac{3}{2}]{w} \propto \sqrt[1.5]{w} \propto W^{\frac{2}{3}}$$

These being all merely different ways of writing it. Hence we see that the energy of birds will only increase as the $\frac{2}{3}$ power of their weight, and that there will be an increase of size beyond which they will not be able to develop the work required for a start.*

But man is also at a further disadvantage. Not only do birds have an enormous muscular development, but their muscles contract at a much more rapid rate than those of other animals. Were men, therefore, not already relatively weaker than smaller animals, in consequence of the physical law which has been stated, they would still be unable to develop energy fast enough to rise on the air with a pair of wings. They can raise their weight, it is true, but not as quickly as the birds. They can run up a stairs at the rate of about 3 ft. per second, while the sparrows rise up vertically at thrice that speed, and fly horizontally at 22 ft. per second.

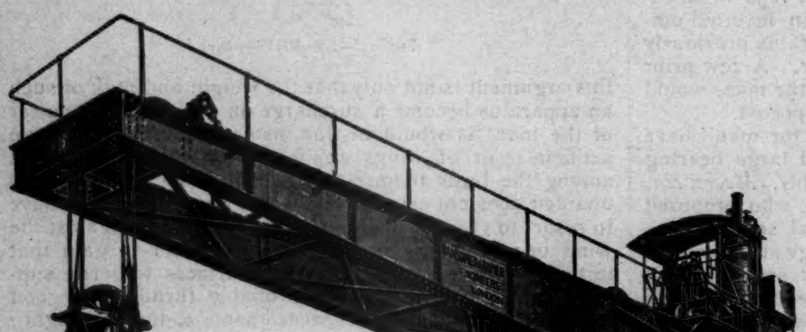
(TO BE CONTINUED.)

* Thus a bird of 50 lbs. weight can do no more work in a given time than $50^{\frac{2}{3}} = 13.57$ similar birds each weighing 1 lb., or a bird of 1,000 lbs., did such a one exist, could only develop the same number of foot-pounds per minute as the aggregate of 100 analogous birds, each of 1 lb. weight.

A LARGE STEAM CRANE.

THE accompanying illustration, from *Iron*, shows a steam "Titan" crane lately completed by Ransomes & Rapier, of Ipswich, England, for the harbor works at Madras, India. It is intended to lift concrete blocks weighing 32 tons each, which are used in building the breakwater. In the illustration it is shown lifting the test load of 40 tons.

All the motions of the apparatus are controlled by a set of levers placed on the platform within easy reach of one man, who has absolute control of every movement of the machine. Its actual weight, without water-ballast or load, is 152 tons, so that when it is traveling with its 40 tons of load and its water-ballast there are 210 tons absolute weight in motion. The momentum is therefore very great, and provision had to be made to reduce this force gradually. The slewing-round gear, for instance, is remarkably free, and 40 tons moving round at a radius of 50 ft. would acquire a momentum much in excess of the actual weight. To provide for easing off this force, spring drivers are introduced in various portions of the gear, and their operation is so successful that the driver may set his engine at full speed in one direction, and then reverse the friction cones to drive in the opposite direction, the engine still running at full speed. Even with such a severe test, no shock is perceptible in any part of the gear. The load swings round in a forward direction for some little time after the gear is reversed; it then comes gradually to a stop without any perceptible jerk, and as gradually starts off in the opposite direction, also without shock.



TITAN STEAM CRANE, MADRAS HARBOR WORKS.

The gearing which causes the crane to travel on the rails is also provided with spring drivers, which enable the engines to make several revolutions before the "Titan" begins to travel, the power having been gradually accumulated in the spring drivers, and as gradually given out. Several other important features are embodied in this "Titan." It has not only, for instance, to swing all round the circle with a full load, but it must also, owing to the shape of the breakwater upon which it is to be employed, be able to travel upon a curved road. To secure this result, the "Titan" is placed upon 12 wheels, in three groups of two each on either side. The outer groups at the four corners are on pivoted trucks; the central groups only are driven, and by means of differential gear on the Jack-in-the-box principle the wheels on the outer curve can travel over a greater distance than those on the inner curve, although both are driven by the same engine. The machine in this respect has been tested in the yard on a curve of 90 ft. radius, and found to answer admirably. The blocks with which the "Titan" will have to deal are seized in powerful claws, which close automatically on the load and raise it by sheer power of grip. When these blocks are suspended over the position they are intended to occupy, there is another automatic appliance by which the claws are made to release their hold. In this way the foundations of the new structure will be laid under water. Subsequently, when more accurate work will be required, the blocks of concrete will be gently lowered down, and adjusted upon the prepared foundation. The "Titan" is made of mild steel, and all the parts are carefully machined and put together with turned fitting bolts, the rivet holes being accurately drilled.

A NEW QUADRUPLE-EXPANSION ENGINE.

THE illustration herewith shows a quadruple-expansion engine, designed by Mr. Frank Chaese, of Hartford, Conn. It is reproduced from a photograph of a complete model made by Mr. Chaese on a scale of ¾ in. = 1 ft., which exactly represents the larger engine. The dimensions of the model are: cylinders, ⅞ in., 1⅜ in., 2 in. and 2⅞ in. diameter, and 1¾ in. stroke. The engine represented has cylinders 14 in., 22 in., 32 in. and 45 in. diameter and 28 in. stroke, and is intended to work with a boiler pressure of 200 lbs.

As will be seen from the cut, the engine is of the vertical, inverted type, with cylinders arranged in pairs. The aim of the inventor has been to make an engine which will still be serviceable after any ordinary accident while at sea. A system of duplication of parts has been carried throughout, and every piece is readily accessible for adjustment or repair, while the space required for the engine, both fore-and-aft and vertically, has been reduced to a minimum. The bearing surfaces are all unusually large, and well supplied with means of lubrication; also with a water service having universal joints for all parts, and hose connections for emergencies.

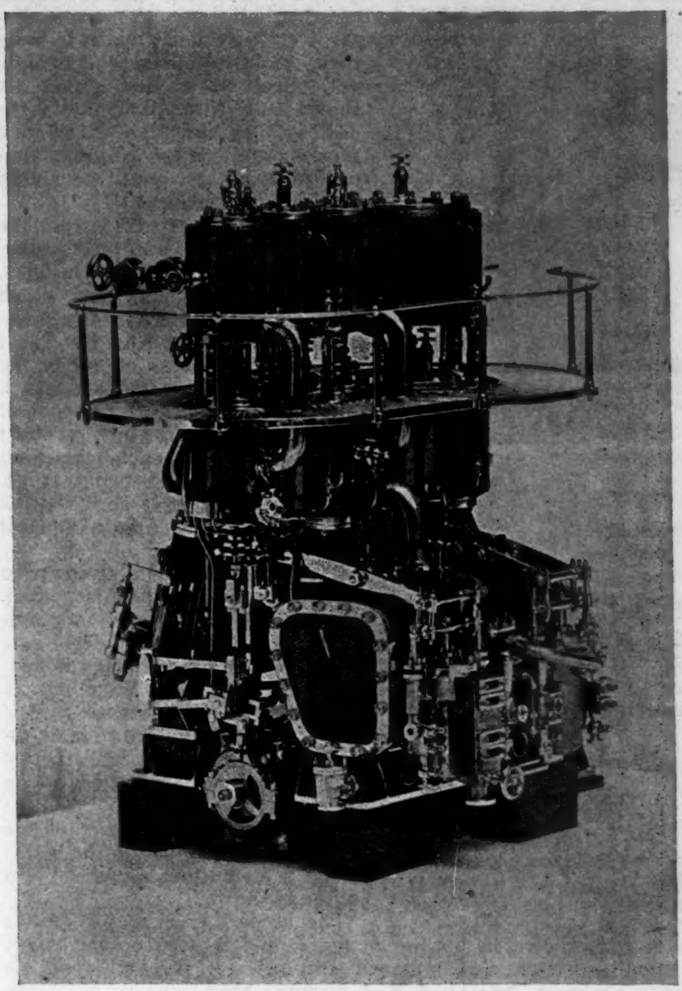
The engine is on the tandem principle, and constitutes two distinct engines, either of which may be used independently of the other in case of breakdown. The high-pressure and first intermediate cylinders form the forward engine, the second intermediate and low-pressure cylinders the after engine.

The crank shaft is made in two similar sections, flanged and connected in the center with a dowel having ample surface, in place of the ordinary coupling bolts; this greatly facilitates disconnecting the engines. In case the forward engine breaks down, the dowel is removed from the shaft and steam let into the after engine through a reducing valve. The after engine then runs as a compound condensing engine. Should the after engine be disabled, the connecting rod is removed from the crank-pin and secured out of the way; connection is made between the first intermediate exhaust and condenser, and the forward engine then runs as a compound condensing engine. The lengths of crank shaft are short, and a spare length is of course carried to provide for accident in this direction. All the necessary valves for these changes are provided. The throttle valve, combined, reducing and blow-through valve, cylinder drain cocks and reversing levers are all worked from the starting platform.

The cylinders are steam-jacketed and dripped into the condenser; they have also a coat of asbestos and a neat wood lagging. Relief valves of ample area are attached to each end of the cylinders, also the necessary indicator

cocks and connections. The main valves are all piston valves, the upper portion being made slightly larger in area than the lower portion ; this perfectly balances all the valve gearing.

The cylinder pistons are attached to their rods by an adjustable screwed collar and nut, which arrangement is quite rigid, but in case of accident allows the pistons to be easily removed ; the lower rods may also be made smaller by this method than by the usual tapered form.



CHAESE'S QUADRUPLE-EXPANSION ENGINE.

The upper cylinders are supported on six short wrought-iron columns, any one of which may be readily removed for packing stuffing-boxes, examining or adjusting pistons or valves.

Split stuffing-boxes and collar bushes are used between the upper and lower cylinders. The long sleeve serves as an excellent guide to the piston rods, while one set of four stuffing-boxes is dispensed with and the vertical height of the engine reduced.

One of the forward columns of the A-frame is used as an oil reservoir ; the go-ahead slides are detachable, the shoes are broad and long and fitted with combs dipping into oil boxes at the foot of the guides in addition to the oil syphon pipes above.

The engine counter is simple in construction, but reliable. It is attached to the after column.

The valve gearing is a modification of the Allen straight link. The link is suspended in such a manner that the slipping of the block in the link is greatly reduced, and a quicker admission and cut-off effected. Reversing is done either by steam or by hand. The hand arrangement is a small force pump connecting to the same oil vessel and levers as the steam reversing gear, a few strokes of the hand-pump being sufficient to reverse the engine.

The steam reverser consists of a steam and an oil cylinder connected together and giving motion to the valve spindles and links. A lever to the steam cylinder, and a two-way valve to the oil cylinder allow the engine to be reversed at will and the cut-off fixed immovably at any point.

In connection with this reversing gear is a positive and very sensitive governor, which has complete control over the main engine at all times through the medium of the links, though it does not interfere with the easy starting, stopping and reversing of the engine. All the eccentrics are keyed on to the shaft in the usual manner, excepting the forward engine go-ahead eccentric. The lead of the latter may be varied according to judgment by a simple device, which is perfectly rigid when locked.

The condenser, it is claimed, is very efficient. Water from the circulating pump is discharged in two directions—around the jacket and through the tubes. Large, easily accessible doors, manholes and handholes are provided ; also a shifting valve at the lowest point. The hot-well has water gauges, vapor pipe and manhole, and forms part of the condenser casting.

All the pumps are worked from the main engine. There are two feed-pumps and two bilge-pumps. Either feed-pump is sufficient for the boiler under ordinary circumstances. They are placed considerably below the hot-well so as to be always flooded, and are provided with stop valves, relief valves, air vessels and pet-cocks. The bilge-pumps are likewise so provided.

The air pump is single-acting, and is placed low down on the condenser to avoid trouble in working.

The circulating pump is double-acting, and of ample capacity for water of all temperatures, the main injection valve being readily accessible. Pipes about the pumps are dispensed with as far as practicable, short passages being cast in the barrels.

There is an auxiliary engine bolted to the bed-plate, a worm from which engages with a wheel on the main shaft. A swinging bracket and clutch allow the worm to be thrown out of gear instantly, as this arrangement is only designed for turning the main engines when overhauling, etc. This auxiliary engine can be used as a powerful pump for all purposes, suitable connections being made to condenser, hot-well, sea and bilges.

Reversing is effected by one lever reversing the steam, cams on the shaft giving the necessary lead and cut-off to the balanced valves, while the absence of connecting and eccentric rods make a remarkably compact machine.

The thrust block has a double set of conical rollers running in oil, which take the full thrust of the propeller. Adjustable plates fore and aft take up the wear.

The general design of the remaining details of the engine is in accordance with modern practise. The model itself is a remarkable piece of work, all the details of the engine being faithfully carried out.

The engine itself appears to be of a very neat and compact design, and to possess some points of excellence which deserve the attention of builders.

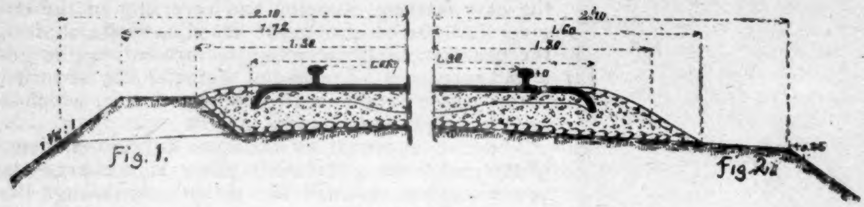
THE SUMATRA STATE RAILROAD.

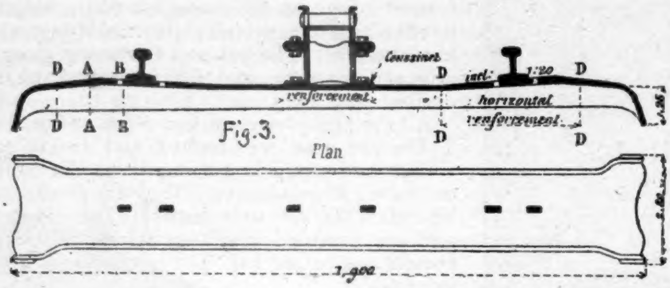
THE first railroad in the island of Sumatra, which is now nearly completed, has been built by the Dutch Government, and a long and interesting account of it is given by Chief Engineer J. W. Post in the *Revue Generale des Chemins de Fer*.

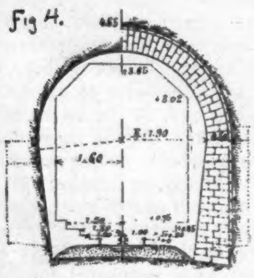
The road extends from Port Emma, the chief Dutch port on the island, to the coal mines of Lounto, with a branch from Padang-Pandjang to Fort de Kock. The line is a very circuitous one, as it was necessary to cross the Barisan mountain range. At Lounto mining has begun on an extensive scale, as the existence there of wide seams of coal of a very fine quality has been proved, and already large quantities have been taken out. In addition to the traffic of these coal mines the road carries a large quantity of

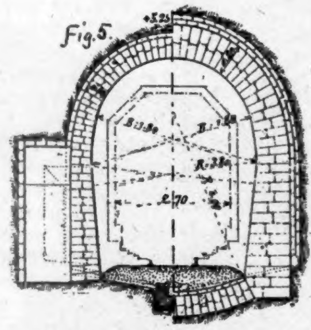
rice, coffee and tobacco from the fertile and thickly peopled districts of Solok and Payacombo, and has already developed a considerable passenger business.

The length of the main line from Port Emma to Lounto is 98 miles, and the branch to Fort de Kock is 12 miles long. The main line is divided into five sections, on three of which the traffic is worked in the ordinary way; on these sections the maximum grade is 1.7 per cent. On the other two sections there are grades as high as 8 per cent., and on these a rack-rail is used. The mountain sections are in all 33 miles long, and there are on them 18 miles of rack-rail in sections varying from 650 ft. to 3½ miles in length. The minimum radius of curvature is 492 ft.









On the main line Lounto is 827 ft. above sea level; the summit is at the Padang-Pandjang Pass, and is 2,532 ft. above the sea. On the branch Fort de Kock is 482 ft. above Padang-Pandjang, and to reach it the line has to pass over the Merapi Pass, where the summit is 3,785 ft. above the sea. On this branch, however, there is no heavy freight, like coal, to be transported.

The line is of 1-meter gauge. The rails are of steel, laid on steel ties. Wood is abundant along the line, but the rapid decay incident to the tropical climate prevents its use. The ballast is generally broken stone. On the level sections in the valleys the line had to be raised on an embankment almost everywhere, to keep it out of danger from floods. Wherever possible the slopes of the embankments are protected by rip-rap. The method of laying and ballasting the road-bed is shown in figs. 1 and 2, fig. 2 being a half section of the normal road-bed, and fig. 1 a half section showing the track at points exposed to inundation. The figures on all the drawings are in meters.

Fig. 3 shows a section and plan of the tie and track where the rack-rail is used. The racks, it will be seen, are bolted to special chairs attached to the center of the tie.

There are two tunnels on the line. The first is 230 ft. long, and is chiefly in solid rock, masonry lining being required for only a short distance. Cross sections of this tunnel are shown in fig. 4, in which one-half shows the section in solid rock, the other half that with masonry lining. The second tunnel is 2,706 ft. long, and is in loose rock, requiring masonry throughout. Sections of this tunnel are shown in fig. 5, where one-half is the ordinary section, the other half showing the section in more compact rock, and also one of the niches provided for trackmen.

As might be expected from the nature of the road and the country, there are many culverts and bridges. The most striking of these, which is shown in fig. 6, is a bridge crossing the gorge of the Anel River; at this point, which is on one of the rack-rail sections, the road has a grade of 6.8 per cent. The span of the central arch is 184 ft.; the short spans are 53 ft. each, the total length of the bridge being 356 ft. In the cut the river is shown at its ordinary level; in time of flood it fills the entire gorge.

Two classes of locomotives are in use on the road. The first, which is employed on the ordinary sections, has outside cylinders, side tanks, four driving-wheels coupled, and a two-wheeled Bissell truck forward. The cylinders are 11.8 × 17.7 in., the drivers are 39 in. in diameter and the truck wheels 25.5 in. The weight of this engine in working order is 43,000 lbs., of which 33,100 lbs. are carried on the drivers and 9,900 lbs. on the truck. In fig. 7 an outline sketch of this engine is shown.

The second type of locomotive is shown in outline in fig. 8, and is used on the mixed adhesion and rack-rail sections. It is carried on six wheels, four coupled as drivers, these being 39 in. in diameter, and a pair of trailing-wheels under the rear end 25.5 in. in diameter, and working in radial axle-boxes. The cylinders are 13.4 × 19.7 in. The connecting rods work an intermediate axle or shaft, *a*, carried in bearings on the frames; this works the shaft *b* by means of geared wheels, and the adhesion drivers *c* and *d* are coupled by parallel rods to outside cranks on the shaft *b*. The toothed wheel which works on the rack-rail is carried on the shaft *b* under the boiler. This arrangement was adopted as being less complicated than the use of separate cylinders for the rack-rail driver. The engine has driver-brakes and also a special brake for use on the rack-rail. As the

heavy grades are all in one direction the locomotive is placed in the rear of the train going up and in front when descending. The total weight of this type of engine, in working order, is 57,850 lbs., of which 15,550 lbs. are carried on the trailing-wheels and 32,300 lbs. on the drivers.

Fig. 7.

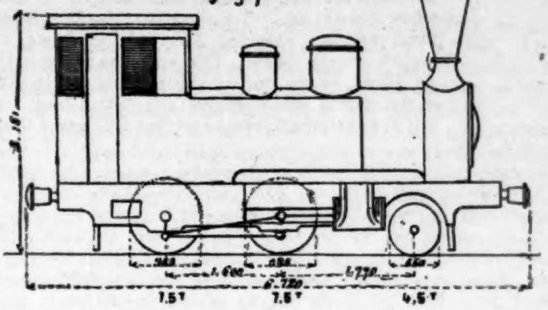
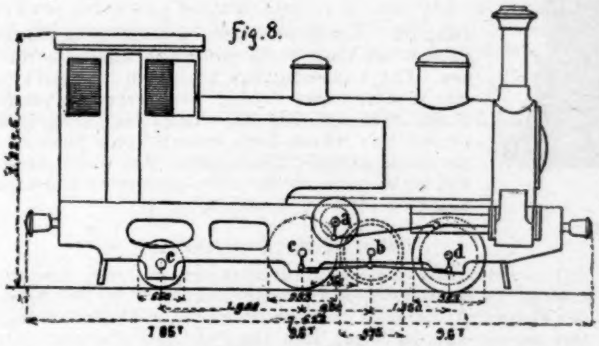


Fig. 8.



The iron-work of the cars was sent from Europe, and the wood-work was done in Sumatra, the timber chiefly used being a native wood called *djatti*. The passenger cars are of the American type, carried on two four-wheel trucks. They are made as open as possible on account of the climate. These cars, which are shown in fig. 9, are 41 ft. long over all, and weigh 25,125 lbs.; the wheels are 31.8 in. in diameter. The roof is of corrugated galvanized iron, and is double, with a space for circulation of air between the outer and inner skins. There are first and second-class cars, which differ only in the arrangement and

Fig. 9.

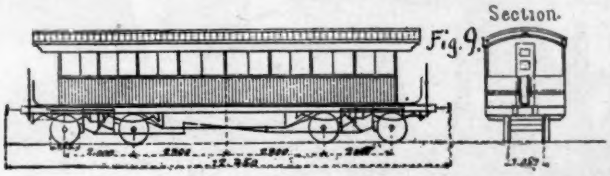
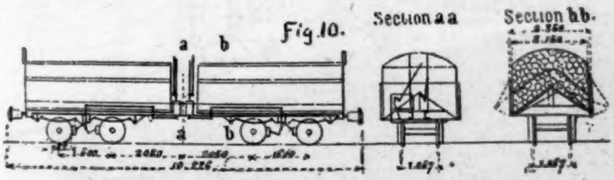


Fig. 10.



finish of the seats, the car bodies being the same. The first-class will seat 48 and the second-class 64 persons.

The freight cars are of three classes, closed or box cars, coal cars and flat cars; they are all the same as to the platform and running gear. They are 33.5 ft. long over all, 7.7 ft. wide, and are carried on two four-wheeled trucks, the wheels being 30 in. in diameter. The box cars, of which only a few are used, have corrugated iron roofs. The coal cars are the most numerous, and are shown in fig. 10. They carry two boxes or bins of iron on the platform, with a space between them, and are arranged to dump at either or both sides, as indicated in the sketch. These cars weigh 20,400 lbs. empty, and will carry 44,000 lbs. of coal.

In building the road native and Chinese labor was chiefly employed. The Chinaman is the same in Sumatra as he is everywhere else; he is there in large numbers, and is an important element in the industrial life of the island. Much of the unskilled labor was done by native convicts. The Malays of Sumatra are not an industrious people, but experience has shown that with instruction and under good supervision they do very well as trainmen, trackmen and in other subordinate positions in operating the road.

Fig. 11

When the line was first opened, a certain suspicious fear of the *carreta api*—the fire-wagon—prevailed among the natives. This has disappeared, however, and they now travel on the road in large numbers. The Malays are a lively people, fond of change and travel, and the second-class fares are very low.

The stations are generally simple in construction, and are of brick or stone, as wood decays very fast. Coal shipping platforms are provided at Lounto; but the most important works of this class are the shipping piers at Port Emma, where there are excellent arrangements for the quick transfer of coal and freight from the cars to ships. At these wharves there are 34 ft. of water at low tide.

As a curiosity, there is given, in fig. 11, an engraving of one of the signs set up to warn travelers at road crossings; the word *djaga* means simply "look out." It may be mentioned, also, that the time-tables and other notices at stations are printed in four languages—Dutch, Malay, Javanese and Chinese. A telegraph line extends along the whole length of the road, and the trains are run on a system very like the American train-dispatching plan.

Plans are in preparation for several extensions of the Sumatran railroad system, and work on some of the new lines will be begun before long.

Foreign Naval Notes.

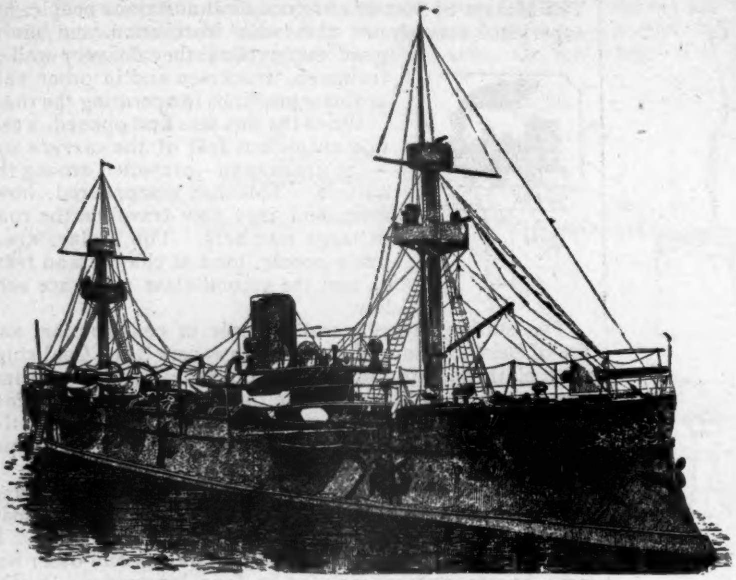
On July 6 the twin-screw armored vessel *Sicilia* was launched from the Government shipbuilding yard at Venice, in the presence of the King and Queen of Italy. This is the tenth ironclad of the first class belonging to the Italian fleet, and was built on the same plans as the *Umberto I.* and the *Sardegna*, being designed by Mr. B. Brin, the late Minister of the Navy Department. The *Sicilia* was commenced November 3, 1884, and the total cost has been estimated at about $5,270,000. Her displacement is 13,250 tons; length, 400 ft.; breadth, 76 ft. 9 in., with a draft of water 28 ft. 9 in. aft and 28 ft. 3 in. forward. The hull of the vessel is made of steel. The engines have been constructed by Messrs. Gio. Ansaldo & Company, of Sampierdarena, and will develop 19,500 H.P. The vessel is expected to attain a speed of 18 knots per hour. The armament will consist of four 12.87-in., 67-ton guns; eight 6-in. guns; six 4.72-in. guns; ten 2.24-in. and seventeen 1.46-in. rapid-fire guns; five torpedo-tubes. The *Sicilia* is one of the heavy armored ships of the Italian Navy which have been severely criticised abroad.

The new British cruiser *Melampus*, during her four hours steam trial, attained an average speed of 18.35 knots an hour, under forced draft. On an eight hours' trial, with natural draft, the engines developed a total of 7,600 H. P., being in excess of contract requirements.

The second-class protected cruiser *Intrepid*, for the British navy, has been launched from the yards of the Glasgow Engineering & Iron Ship-building Company. The *Intrepid* is a sister ship to the *Indefatigable* and *Iphigenia*. She is 300 ft. long, and has 43 ft. 8 in. beam. Her displacement is 3,000 tons. Her speed is estimated at 20 knots an hour. She is propelled by two sets of triple-expansion engines of 9,000 collective H. P. Steam will be supplied by five boilers working at 155 lbs. steam pressure. The cylinders measure 32½, 49 and 74 in. in diameter. The *Intrepid's* battery consists of two 6-in. rifles, six 4.7-in. rapid-fire guns in central pivot mount, eight 6-pdr. Hotchkiss, one 9-pdr. field gun, one 3-pdr. Hotchkiss, four 4.5-in. five-barreled Nordenfelt guns, and four 14-in. Whitehead torpedoes. The 4.7-in. guns are to be placed on the broadside upper deck. The complement of the *Intrepid* is 252 officers and men.

An eminently successful trial of a Thornycroft torpedo-boat, built for the Brazilian Government, is reported from England.

The new boat is 150 ft. long and 14 ft. 6 in. beam. The trial consisted of two parts—first, a series of six runs on the measured mile, with a load of nineteen tons on board, during which a speed of 25 knots was guaranteed by the builders, and, secondly, a continuous run of two hours' duration, during which a speed of 24 knots was guaranteed. The mean speed obtained in six runs was 25.858 knots. Messrs. Thornycroft thus more than fulfilling the contract. In the subsequent two hours' trial the vessel averaged 25.387 knots, which is claimed to be the highest speed hitherto maintained by a torpedo boat for that length of time. The armament of the new boat is somewhat peculiar, there being four torpedo guns suited for the 14-in. Whitehead torpedo, instead of three suited for the 18-in. torpedo, as in the Argentine boats. Two of these torpedo-tubes are mounted on racers on deck, and two under deck in the bows, arranged not in the ordinary way, but with gear, enabling them to be protruded through doors in the skin of the boat. These doors, when closed, form a continuous surface with the skin of the vessel, thus presenting no obstruction to the seas, and lessening the broken water and spray which is so easily illuminated by the electric light. When the torpedo guns are run out the torpedo is guided beyond the line of the stem, thus obviating the risk of deflection arising from the pressure of the issuing gases between the torpedo and the skin of the ship. In addition to this armament the little vessel carries two 3-pdr. quick-firing Nordenfelt guns mounted on recoil carriages. The machinery consists of two sets of triple-expansion engines, supplied with steam by two Thornycroft boilers.



CHILEAN CRUISER "PRESIDENTE ERRAZURIZ."

THE Russian Navy is being increased with remarkable rapidity, not only in the Baltic, but also in the Black Sea. At the present moment all the ship-building yards in Russia are engaged in the construction of iron-clads and monitors. At the Baltic Works the immense cruiser *Rurik*, of 10,000 tons displacement, and capable of steaming 20 knots an hour, is being built, and at the Franco-Russian Works an iron-clad, the *Navarino*, of 9,476 tons displacement, is on the stocks. Another iron-clad is being built at the new Admiralty Wharf in St. Petersburg. At the Nevsky Works an iron corvette and a large ice-breaker are on the stocks, while at the Pvotieloff Works two sea-going monitors are under construction. In all, the Russian Government has 22 ships of war in course of construction, and many more orders have been given.

FRENCH TORPEDO BOATS.

IN last year's naval maneuvers so much trouble was experienced with the torpedo boats in the French navy that it was resolved to reconstruct those of the 35-meter class so as to give them additional stability. The want of stability was found to result chiefly from the cross-section adopted for these boats, with sharply re-entering sides nearly flat. To remedy this the form has been entirely changed for over one-third of the length of the boat. The accompanying cut, from *Le Yacht*, shows one of these boats as altered, and in fig. 2 is a cross-section, the dotted line *A* showing the original form, and the full line *b* that now

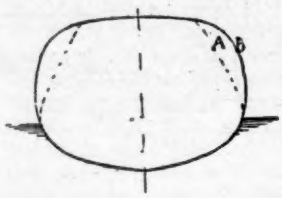
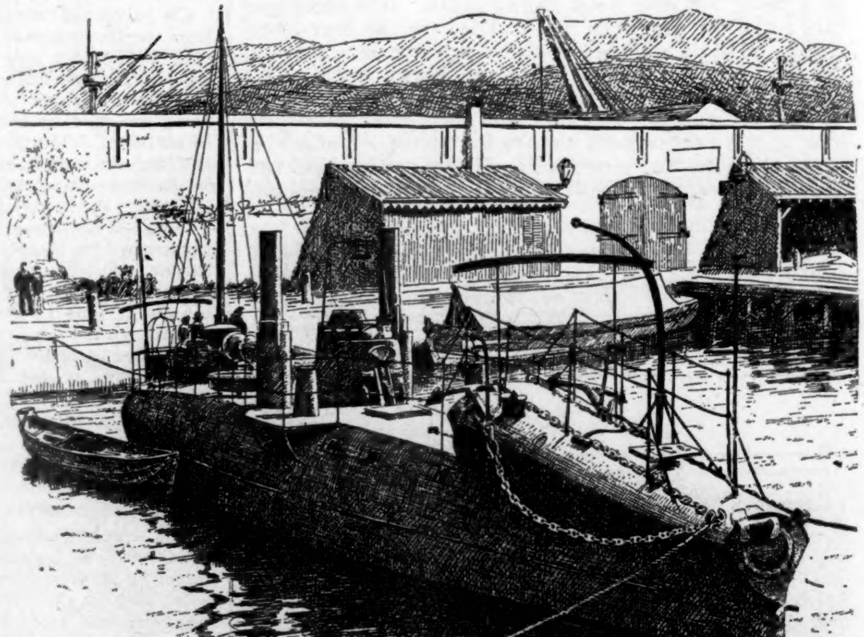


Fig. 2.

adopted. The forward lines have also been changed to give the boats better protection against a rough sea. The armament has also been changed; formerly these boats carried two torpedo-tubes forward, but now they have only one forward, the second one having been mounted on a pivot aft of the smoke-stack. It is believed that these changes will make them much more seaworthy and useful boats.

THE "PRESIDENTE ERRAZURIZ."

THE accompanying illustration shows the new protected cruiser, *Presidente Errazuriz*, lately completed by the Société des Forges et Chantiers de la Mediterranée, at Toulon, France; this cruiser and its sister ship, the *Presidente Pinto*, attracted much attention, on account of the uncertainty as to their ownership previous to the success of the late revolution in Chili.



FRENCH TORPEDO BOAT, 35-METER CLASS.

The *Presidente Errazuriz* was ordered by the Chilian Government in 1888, and is a protected cruiser 268 ft. in length, 36 ft. beam and 2,080 tons displacement. She has a protective deck varying in thickness from 1.5 to 2.4 in., and extending 28 in. below the water-line. The engines have worked up to 5,400 H.P., and the ship has shown on trial a speed of 15 knots with natural draft and 19 knots with forced draft. The coal bunkers

will hold coal enough to give her a cruising radius of 4,500 knots at a 12-knot, or 2,550 at 15-knot speed.

The main battery consists of four 15-cm. (5.9-in.) and two 12-cm. (4.7-in.) Canet guns. The secondary battery includes four 47-mm. (1.85-in.) and four 37-mm. (1.46-in.) revolving cannon and one Nordenfelt machine gun; there are also three torpedo-tubes.

AN ENGLISH PNEUMATIC GUN.

A new torpedo gun has been invented by J. E. Bott, an engineer of Manchester, England, and is shortly to be tried. The descriptions so far given are not very definite, but from them it would seem to differ from the Zalinski gun in having no machinery for compressing air attached to the gun itself, and in giving a sudden impulse to the projectile, instead of a continued pressure. A breech-loading smooth-bore gun is used, and it is calculated that shells can be thrown three miles. Any smooth-bore cannon of large caliber can be used, with some slight changes in the breech. The shell itself is divided into two chambers, the forward one, about one-fourth of the whole length, containing the charge of dynamite or other high explosive, provided with the usual fuse or detonator. The rear chamber, occupying about three-fourths of the shell, is filled with compressed air at a very high pressure. When the shell is placed in the gun, a pin in the breech is operated so as to force back or cut away aretaining valve or plug in the rear end of the shell, and the compressed air thus suddenly released impinges on the breech of the gun, giving the shell its forward impulse.

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

(*Continued from page* 473.)

(Correction.—Through an error of the printer, the numbers of figs. 334 and 335, in the article on The Essentials of Mechanical Drawing, published last month, were transposed—that is, fig. 334 should be 335 and 335 should be 334.)

CHAPTER XIII.—(*Continued.*)

INVOLUTE TEETH.

It remains to explain how to find the diameters of the base circles of wheels with involute teeth. From fig. 340 it is obvious that the teeth of the wheel and pinion are in contact with each other on the line *v P w*, which is therefore called their *line of action*, which is tangent to the base circles *r d' t* and *R d T*. If, now, from the tangent points *v* and *w* of the line *v P w* with the base circles we draw radii *v b* and *w D*, to the center of the pinion and wheel, we will have two similar triangles, *b v P* and *D w P*, so that, by a well-known principle of geometry, their sides will be proportional—that is, *D w*, the radius of the base circle of the wheel, will bear the same proportion to *b v*, the radius of the base circle of the pinion, that *D P*, the radius of the pitch circle of the wheel, bears to *b P*, the radius of the pitch circle of the pinion. Therefore the base circles bear the same proportion to each other that the pitch circles do, which is one of the conditions which they must fulfil. It can be proved by the same demonstration that if we draw a line of action, *v P w*, at any angle to the center-line *b P D* and draw base circles tangent to this line, that they will bear the same proportion to each that the pitch circles do. Therefore the line of action may have any angle to the center-line. It remains to show what angle is preferable.

Suppose that the pinion in fig. 341 has 12 teeth, which is the smallest number that will work satisfactorily with involute teeth; and that the pinion gears into a larger wheel, and that *h v* is the outline of a tooth of the pinion and *v o* that of a tooth of the wheel, *E F G* and *e f g* being the addendum circles. It is plain that the tooth *h v* of the pinion cannot come in contact with *v o* of the wheel until the outline of *h v* intersects the addendum circle *E F G* at *v*. Consequently, in order that the teeth may have as long a line of action as possible, it should be drawn through *v* and *P*, the pitch-point, which determines the angle of the line of action with the center-line *b P D*; but if the diameter of the wheel was increased the point of intersection, *v*, would be moved toward *n*. If the radius of the wheel was infinitely long, the pitch circle *A P C* and the addendum circle *E F G* would become straight lines. In order that gear wheels may be interchangeable, it is desirable that the smallest practicable pinion may gear into a wheel with the longest radius, which would be a straight rack, whose radius is of infinite length. Therefore, lay off from *P*, the depth *P F* of the addendum of the tooth of the wheel, from the pitch-line and draw a straight line, *S F s*, through *F* and perpendicular to *b P D*, the center-line.

It has been explained that if a radius, *b v*, fig. 340, be drawn through *b*, the center of the pinion, and *v*, the tangent point of the line of action *v P* with the base circle, that we will have a right-angled triangle *b v P*. If, now, on the radius *b P*, fig. 341, as a diameter, a semi-circle, *b k P*, is drawn, intersecting *S f s* at *n*, and a line, *b n*, is drawn through the center *b* and *n*, and another line, *n P*, be drawn through *n* and the pitch-point *P*, then the triangle *b n P* being inscribed in a semicircle will have a right angle at *n*, and if a base circle, *r n a' t*, be drawn from the center *b* with the radius *b n*, it will fulfill all the required conditions—that is, a tooth of the pinion would first come in contact with a tooth on the rack at *n*, so that *n P* would give the longest possible line of action, and *n P* will be tangent to the circle drawn through *n*, and will pass through *P*, the pitch-point. If the pinion gears into a wheel, *n P* should

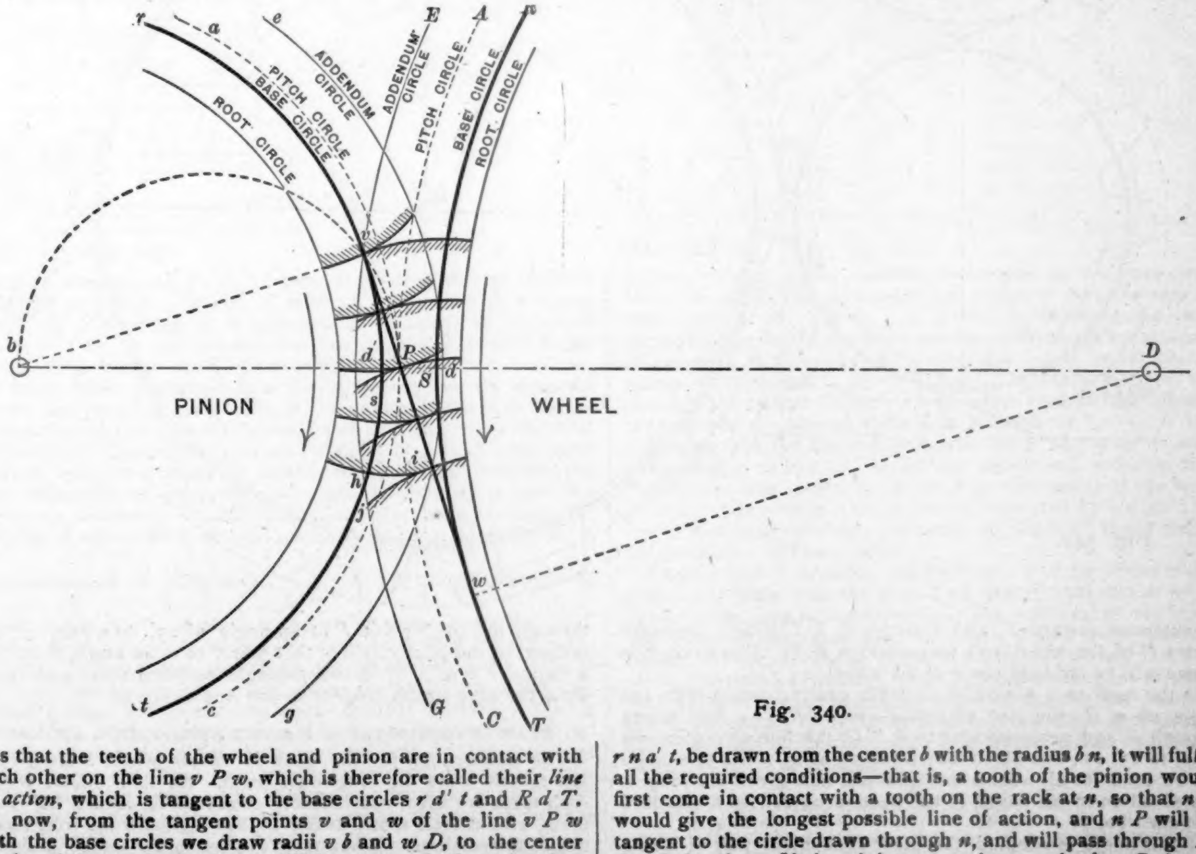


Fig. 340.

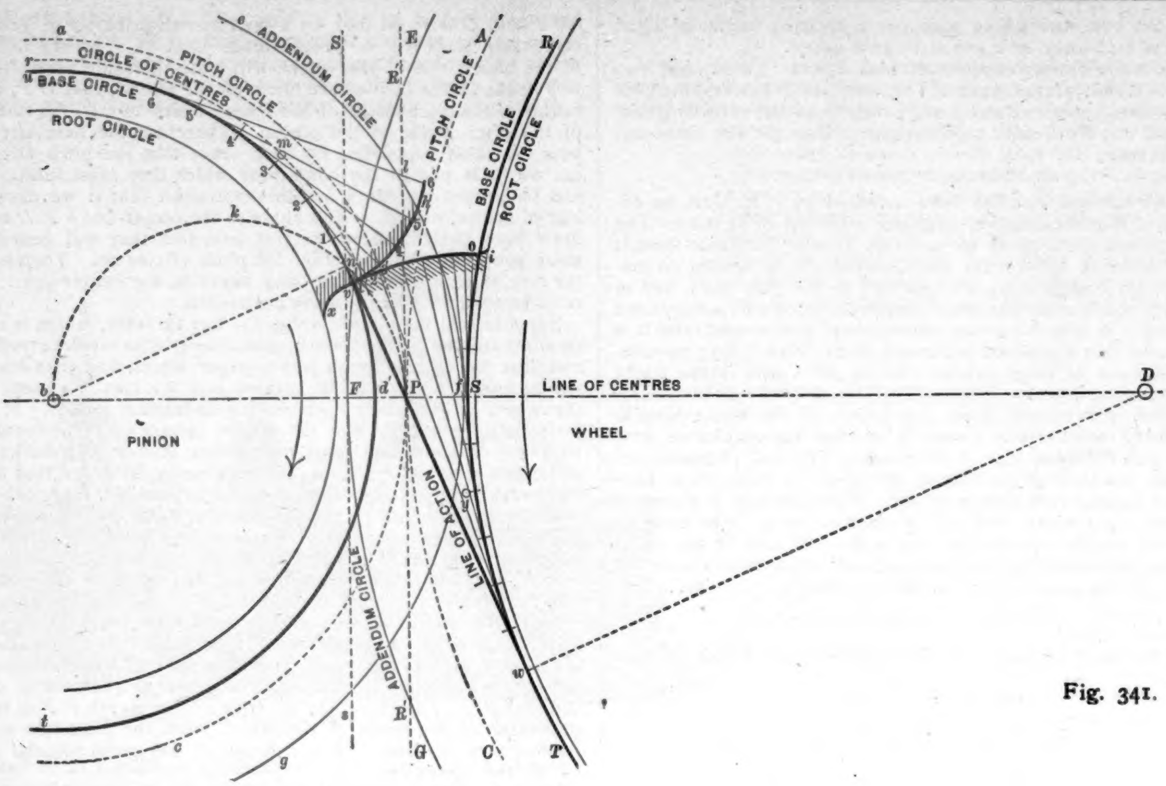


Fig. 341.

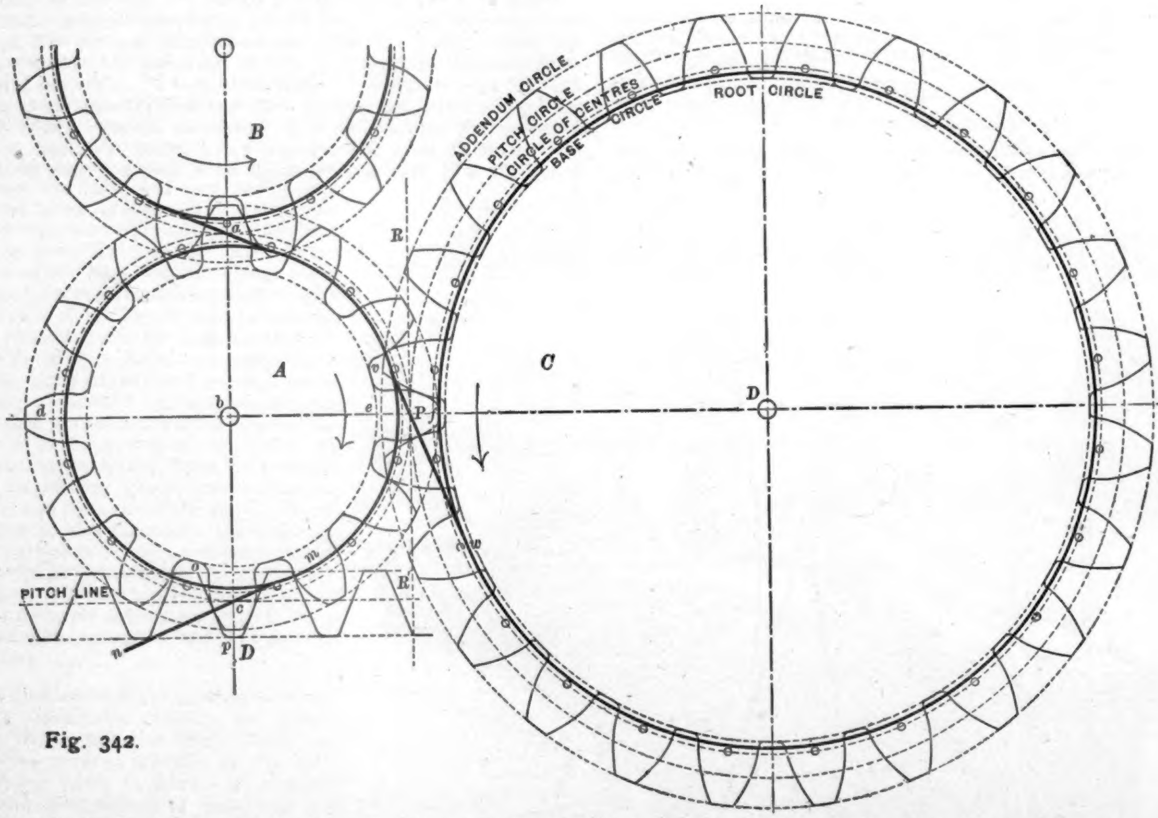


Fig. 342.

be extended toward *T*, and a circle, *R S T*, drawn from the center *D* of the wheel and tangent to *n P T*. The circle thus drawn will be the base circle of the wheel.

In the case of a pinion of 12 teeth gearing into a rack, the angle of *n P*—the line of action—with *l P G*—a line drawn through *P* and perpendicular to *b P D*, the line of centers—is equal to 23° 21′, but which may be taken at 23°. As this angle can be used for all wheels and pinions, and gives the longest line of action in all cases, it has been proposed as a standard for gear wheels.

If this angle is adopted, the most convenient way of laying out the base circles is by simply drawing the line of action through the pitch-point *P* at an angle of 23°, to a line, *l P G*, tangent to the pitch circle at that point, or at an angle of 67° to a radius, *b P* or *D P*, drawn through the pitch-point and then draw the base circles tangent to this line of action.

TO DRAW INVOLUTE TEETH FOR A WHEEL, PINION AND RACK.

The proportions for the teeth of wheels, which were given last month, were for rough-cast teeth. As then stated, when such teeth are used, considerable clearance is needed between them, and at their roots, owing to the roughness and irregularities of the castings. When teeth are cut in a machine, and are thus of a more exact form, less clearance is required, and they

may be made of the same thickness, or very nearly so, as the spaces between them, and only about half as much room need be allowed between the tips of the teeth of one wheel and the bottom of the spaces. The following are good proportions for teeth which are "cut" or finished on a machine:

PROPORTIONS FOR CUT TEETH OF GEAR WHEELS.

P = Pitch which is divided into 16 parts.
T = Thickness of tooth measured on pitch circle = 8 parts.
S = Space between teeth measured on pitch circle = 8 parts.
d = Depth from pitch circle to tip of tooth = 5 parts.
D = Depth from pitch circle to base of tooth = 6 parts.
$D + d$ = Whole depth of tooth = 11 parts.
R = Thickness of rim and arms of wheel = 9 parts.
L = Length of tooth measured parallel to axis of wheel = 2 or 3 times the pitch or 3 P.

To illustrate how the teeth of different wheels are laid out, a pinion, A, with 12 teeth has been represented in fig. 342,* geared

subdivided into the required number of divisions in one operation.

Having divided the pitch circle the width of the teeth = one-half the pitch should then be laid off on the pitch circle. The depth $P f$ from pitch circle to the tip of the teeth and the depth $P e$ from pitch circle to the base or root of teeth should then be laid off, and the addendum and root circles drawn through these points. Then through the pitch-point P draw the line of action $v P$ at an angle o 23° to a line, $R R'$, perpendicular to the line of centers $b P D$, and from the center b of the pinion draw a circle tangent to $v P$. This will be the base circle of the pinion from which the involute curve, which forms the outline of the teeth, must be drawn. The method of doing this was explained in Problem 97, of Chapter XI., but a little further explanation may make the method of doing it clearer.

Referring to fig. 341, let it be supposed that the outline of a tooth is to be drawn through the point v. First lay off from v, on the base circle $u v d'$, a number of equal spaces, 1, 2, 3, etc.

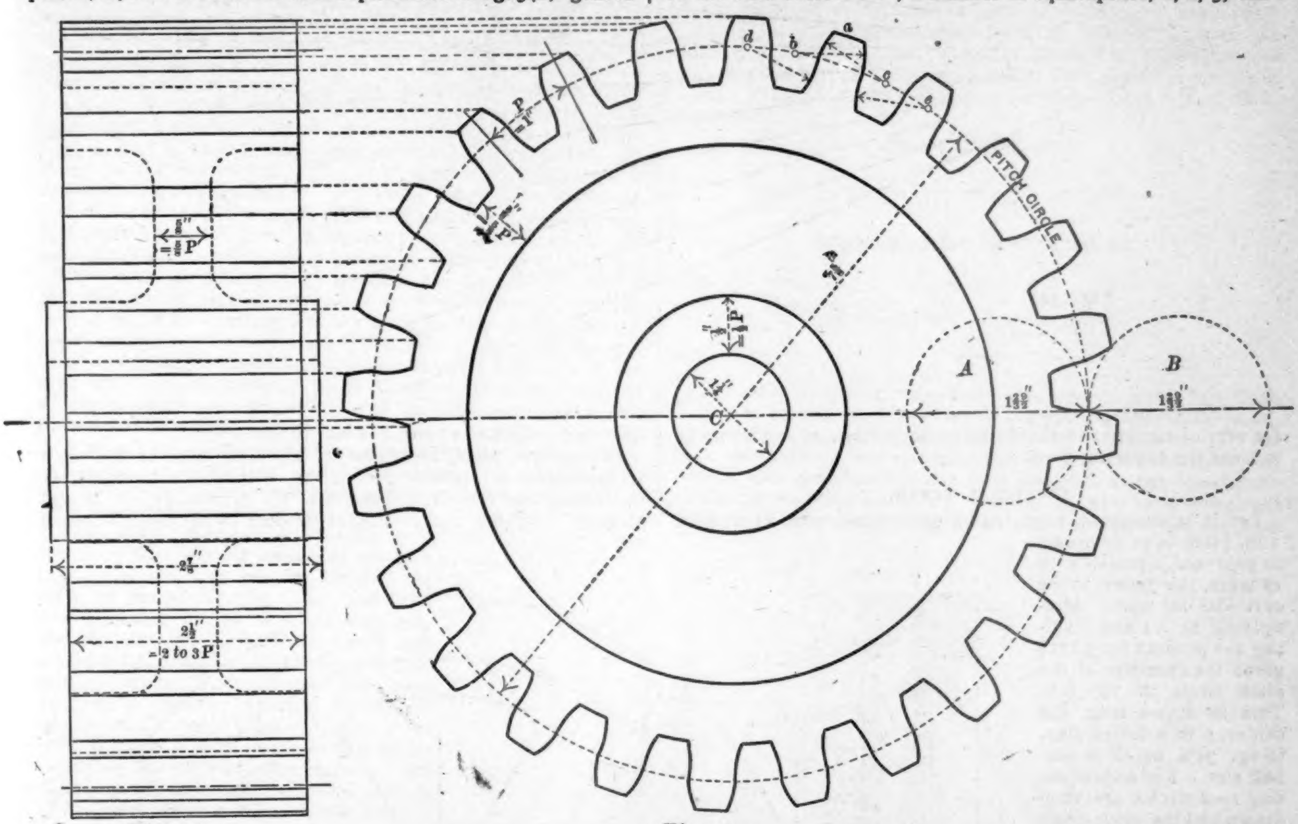


Fig. 344.

Fig. 343.

nto another pinion, B, of the same size—only half of which is shown—and into a wheel, C, with 24 teeth, and also into a rack, D. The drawing is supposed to be drawn to a scale of 3 in. = 1 ft., or one-quarter size the pitch of the teeth being 2 in. The learner should draw this full size.

It has been explained that the *pitch*—that is, the distance from the center of one tooth to the center of the next one, is measured on the pitch circle, and is an arc, and not a chord of the circle. Consequently, if we multiply the pitch by the number of teeth in a wheel or pinion, will give the length of the circumference of the pitch circle, and dividing by 3.1416 will give its diameter. In the example under consideration the pinion A has 12 teeth of 2 in. pitch, so that $2 \times 12 = 24$ in. = circumference of pitch circle, $\frac{24}{3.1416} = 7.67$ in. = diameter of pitch circle $a\ P\ c\ d$ which is drawn of that diameter = $7\frac{11}{16}''$ full. With a pair of dividers this circle is divided into 12 equal parts. In doing this, especially if a wheel has many teeth, it will be found advisable to first divide the circle into parts containing some multiple of the whole number of teeth, if that is possible. Thus, in the present instance, the pinion has 12 teeth, so that the pitch circle may be first divided into four equal parts, and these can then be subdivided into three parts. By adopting this method the division can be made more quickly and with greater accuracy than is possible if the pitch circle is

* This diagram is an imitation of one in Thorne's book on Mechanical Drawing.

Through these points draw lines tangent to the base circle. With the same space between the points of dividers step off, from each of the points, 1, 2, 3, etc., on the tangents drawn through these points, the same number of divisions as each point of tangency is from the point of origin v, and mark the final points of division at 1', 2', 3', 6', etc. Then draw a curve, $h v$, through the points 1', 2', 3', etc., which will be the required involute and the outline of the face of the tooth.*

Having laid out the outline of the tooth, find with a pair of compasses a center, m, of an arc which will coincide most closely with the involute. Then from the center of the wheel draw a circle called a *circle of centers* (indicated by a dotted line in the engraving) through this point, on which all the centers of the tooth-arcs will be located.

The method of drawing the outline $v o$ of the wheel will be sufficiently plain from the preceding description, and from the construction lines in the drawing. The outlines of the opposite sides of the teeth are, of course, drawn with the same radius. If the thickness of the teeth is set off on the pitch circle, the radius of the arc, which approximates most closely to the outline of the teeth, and the circle of centers has been laid down, the simple problem then is to draw such arcs through the points laid off on the pitch circle from a center which must be on the circle of centers.

* This method is not absolutely correct, for the reason that the space between the points of the dividers with which the spaces 1, 2, 3, etc., are stepped off is equal to the chord of the arc included, which is somewhat less than the length of the arc itself. If the spaces are short, no appreciable error will result by adopting this method.

The portion of the flank of the tooth lying within the base circle may be a radius to it and tangent to the involute. In order to strengthen the teeth small fillets should be drawn at their roots connecting them with the root-circles. These fillets are arcs of circles, and should be made as large as can be made to clear the engaging teeth.

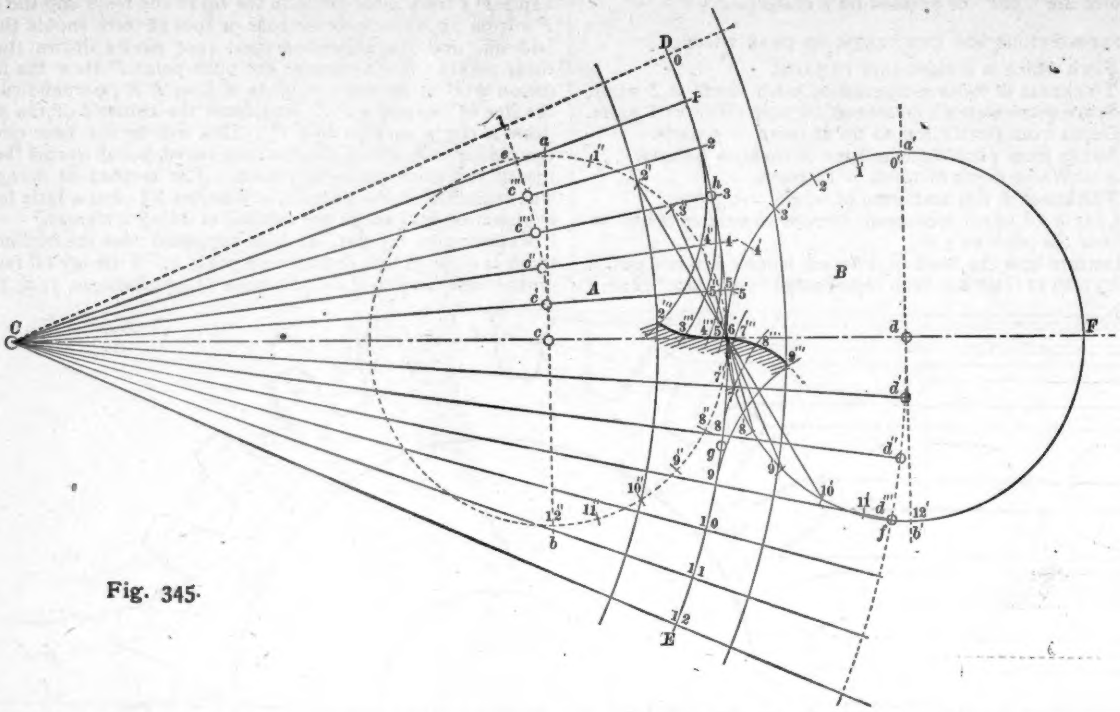


Fig. 345.

CYCLOIDAL TEETH.

Let it be supposed, now, that a gear wheel with 24 teeth of 1 in. pitch is to be drawn to gear into a pinion with 12 teeth, the latter to be cycloidal in form. Multiplying 24 × 1 and dividing the product by 3.1416 gives the diameter of the pitch circle = $7\frac{5}{8}''$ full. This is drawn from the center *C* in a dotted line, in fig. 343, which is one-half size. The addendum and root-circles are then drawn and the pitch circle is first divided into four equal parts, then into eight, and finally into 24 = the number of teeth. It being supposed that the teeth are to be cut on a machine, their thickness is laid off on the pitch circle = ½ *P*. As the wheel is to gear into a pinion with 12 teeth, which would be one-half the diameter of the wheel, the generating circles *A* and *B* are taken at one-fourth the diameter of the wheel = $1\frac{29}{32}''$. To lay out the form of the teeth an arc, *D E*, of the pitch circle is drawn full size from the center *C*, in fig. 345, and the generating circles *A* and *B* are also drawn on the line of centers *C F* and tangent to the pitch circle at 6. The problem now is to describe an exterior epicycloid on the outside of the pitch circle, which would be generated by a point, 6, on the circle *B* in rolling on the outside of arc *D E*, and also to draw an interior epicycloid which would be generated by a point, 6, in the circle *A* in rolling on the inside of the arc of the pitch circle. The method of drawing such curves was described in Chapter XI., Problem 93, but a little further elucidation of the method of doing it will be given here.

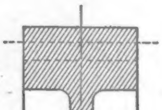


Fig. 347.

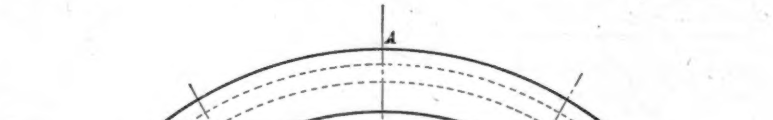


Fig. 346.

In the first place, ascertain the circumference of the pitch circle, which, in drawing the curves, will be the fundamental circle, and also the circumference of the generating circle, and multiply it by 360° and divide the product by the circumference of the pitch circle. This will give the number of degrees of the angle which will include an arc of the pitch circle of equal

length to the circumference of the generating circle. From the center C lay off an angle, $D\ C\ E$, but for convenience make this only half as large as the angle which has been calculated. Then the arc $D\ 6\ E$ will be equal in length to one-half the circumference of A and of B. Divide the arc $D\ 6\ E$ into any even number of equal parts, 0, 1, 2, 3, etc., and the semi-circumferences $a\ 6\ b$ and $a'\ 6\ b'$ of A and of B into the same number of equal parts, letting points of division coincide at 6. Through the center C of the pitch circle $D\ 6\ E$ and the points of division 0, 1, 2, 3, etc., of that circle, draw radii C 0, C 1, C 2, etc. From C as a center draw arcs $e\ c$ and $d\ f$ through the centers c and d, and extend the radii C 7, C 8, C 9, etc., to intersect $d\ f$ at d', d'', d''', etc. From 6 draw chords, 6 2'', 6 3'', 6 4'', 6 5'', 6 7', 6 8', 6 9', 6 10', to the points of division of the generating circles. Then from the centers d', d'', and d''', with the radius of the generating circles, draw arcs 7 7''', 8 8''', 9 9''' tangent to the pitch circle. Take with a pair of dividers the length of the chord 6 7', and set this distance off on the arc from 7 to 7''' and mark the point 7'''. In the same way take the length of the chord 6 8' and set it off on the arc from 8 to 8''', and also the chord 6 9' on the arc 9 9'''. Then a curve drawn through the points 6, 7''', 8''', 9''' will be the outline of the face of a tooth. From the points of intersection c', c'', c''', c'''' of the radii with the arc $e\ c$, as centers, draw other arcs, 2 2''', 3 3''', 4 4''', 5 5''', and set off on them from 2, 3, 4, and 5, in the same way as has been explained, the length of the chords 6 2'', 6 3'', 6 4'', and 6 5'', then a curve drawn through the points 2''', 3''', 4''', 5''', 6 will form the outline of the flank of the tooth. Having laid down these curves, find centers g and h, from which arcs may be drawn, which will approximate as closely as possible to these curves. In the present example these centers are both on the pitch circle. If they should be without or within it, their position should be laid down on the drawing and circles of centers drawn through them, on which all the centers of the arcs which form the outlines of the teeth would be located. Having the radii of the arcs which approximate to the outlines of the teeth, and the circles of centers and the thickness of the teeth being laid down, they are then readily drawn. Their correct outline may also be laid out by the mechanical method described in the article published last month, and illustrated by fig. 339. A fillet, 2''', fig. 345, should also be drawn at the roots of the teeth to strengthen them at that point.

The usual method in drawing gear wheels with cycloidal teeth is to take the centers of the arcs for the faces of the teeth on the pitch circle, in the middle of the adjoining spaces between the teeth, and that for the flank of the teeth also on the pitch circle in the middle of the adjoining teeth. This method has been adopted in drawing fig. 343, the centers of the faces of tooth a being taken on the pitch circle at b and c in the middle of the adjoining spaces, and the centers of the flanks are taken at d and e, in the middle of the next teeth. When this is done, it must be left to the pattern-maker or machinist to lay out the exact form of the teeth. It is well in all cases where a correct form is desired to give a separate drawing, similar to fig. 345 or fig. 339, showing the method and the exact dimension to be used in laying out the teeth.

In making small gear wheels, it is customary to make the center or the part between the hub and the rim of the form of a plate or disk, as shown in fig. 343. Larger wheels have spokes. The following are good proportions for different parts of gear wheels:

Thickness of rim below the bottom of teeth = $\frac{5}{8}$ pitch.

Thickness of plate between hub and rim of plate wheels = $\frac{1}{2}$ pitch.

Depth of web below rim of a wheel with arms = $\frac{1}{2}$ pitch.

Width of arms at the web for wheels with, say, less than 50 teeth = $1\frac{3}{8}$ pitch.

Width of arms at the web for wheels with, say, over 50 teeth = $1\frac{5}{8}$ pitch.

Width of arms to be tapered from $\frac{11}{16}$ in. to $\frac{3}{4}$ in. per foot of length.

Thickness of arms $\frac{1}{2}$ of their width.

Thickness of web inside of rim is the same as that of the arms which join it.

Diameter of hub $1\frac{3}{4}$ to 2 times the diameter of shaft.

Length of hub not less than $1\frac{1}{2}$ times the diameter of the shaft.

In making working drawings it is a very common practice to draw only the outside or addendum circle and the pitch circle, and show only a few of the teeth, as represented in fig. 346. This shows a gear wheel with 48 teeth of 1 in. pitch engraved to a scale of 3 in. = 1 ft. The student should draw it full size. What has been said of the proportions of the spokes, rim, etc., and the explanation of the method of drawing pulleys, in Chapter VI., makes any further directions for drawing these parts of a wheel unnecessary. It is customary to show one view of such wheels in section, fig. 347, as in this way the proportions of the hub, arms, rim, etc., can be shown more clearly than by an external view. The section is supposed to be on the line $A\ B\ C$, so that in the top portion the shape of the rim is represented and in the lower part that of one of the arms. The sections of the arms are supposed to be elliptical in shape, but such arms are sometimes made of cruciform, T or I shape, although this practice has now to a great extent gone out of fashion.

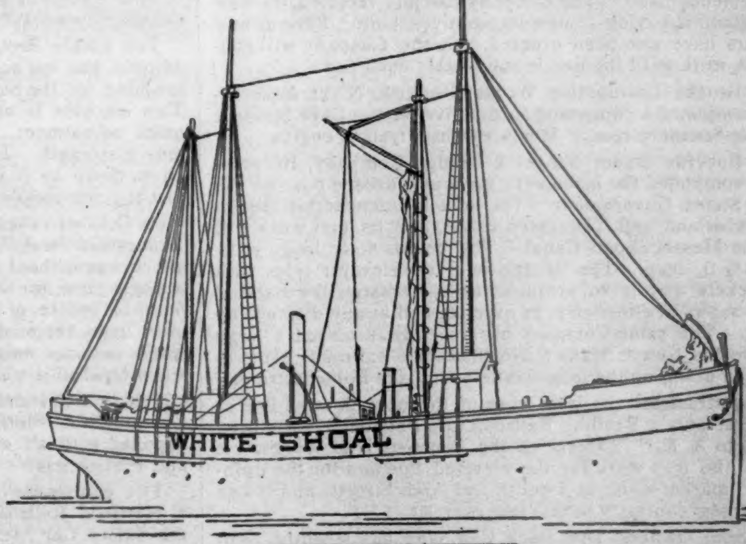
The number of arms in wheels is fixed very arbitrarily. Unwin, in his "Elements of Machine Design," makes the general observation that "usually there are four arms for wheels not exceeding 4 ft. in diameter; six arms for wheels of from 4 ft. to 8 ft.; and eight arms for wheels from 8 ft. to 16 ft. diameter."

(TO BE CONTINUED.)

Lightships for Lake Stations.

(From the Cleveland *Marine Record*.)

THE accompanying cut shows the type of three lightships built for service and now ready for placing on White Shoal, Simmon's Reef and Gray's Reef, Lake Michigan. Eleven lake shipbuilding firms made bids for their construction last March, and the contract was duly awarded to the lowest, the Craig Shipbuilding Company, Toledo, O., who have completed their work under a Government superintendent of construction



LIGHTSHIP FOR LAKE MICHIGAN.

according to the specifications of the Lighthouse Board. These vessels are notable on account of being the only lightships under Government jurisdiction now afloat on the lakes, and they mark an era in the systematic lighting of channels, fairways and dangers which has long been sought by the lighthouse officials in charge of the lake districts, the vessel owners and kindred interests. Their dimensions are 100 ft. over all, 21 ft. beam, and 14 ft. deep (molded). Engines, cylinders 14 × 15 in., speed about 6 miles per hour.

The cost of construction for the three lightships was $44,429, or nearly $14,810 each, including windlasses, fog whistles, trysail masts and extras.

Manufactures.

General Notes.

THE office of the Lappin Brake Shoe Company has been removed to Room 406, Welles Building, No. 18 Broadway, New York.

THE Cooke Locomotive Works, Paterson, N. J., are building 25 engines for the Chicago, St. Paul & Kansas City Railroad.

THE largest fly-wheel in the country, it is claimed, is in the new power-house of the West End Street Railroad, in Boston. The wheel is 28 ft. in drameter, 10 ft. 7 in. face, and weighs 80 tons. It carries two 54-in. belts, and the velocity of the rim is 6000 ft. per minute.

THE American Steel Wheel Company has decided to remove its plant from Boston, and to put up extensive buildings at a point where materials and fuel can be had at lower cost for freight. A point on the line of the Central Railroad of New Jersey, some 20 or 25 miles from New York, will probably be selected.

RECENT orders for locomotives include one for 35 given to the Brooks Locomotive Works by the Lake Shore & Michigan Southern Company. The Boston & Albany has placed an order for 25 engines with the Rhode Island Locomotive Works in Providence.

THE St. Charles Car Company has an order for 300 coal cars of 60,000 lbs. capacity for the Texas & Pacific. This company has also an order for two first-class chair cars for the Toledo, St. Louis & Kansas City road. They will be mahogany finish, with spacious smoking room and complete buffet, and will be very handsome cars.

THE Grant Machine Tool Works has recently established at Fitchburg, Mass., works for making by new process anti-friction steel balls, ball bearings, and specialties of steel. They will also make the standard brake-pin. Mr. R. H. Grant is Superintendent, and John J. Grant, formerly of the Simonds Rolling Machine Company, is General Manager.

FEW roads in the Central States have made greater improvements recently than the Toledo, St. Louis & Kansas City, under the presidency of S. R. Callaway. A large quantity of new steel has been put down, the track ballasted, and other improvements made. The company has just received 500 new box-cars and is having 10 new locomotives built. Several new chair cars have also been ordered, and the company will continue the work until the line is completely equipped.

THE Brooks Locomotive Works, Dunkirk, N. Y., have recently completed a compound locomotive for the Lake Shore & Michigan Southern road. It is a 10-wheel freight engine.

THE Bucyrus Steam Shovel & Dredge Company, Bucyrus, O., has completed the machinery for a new dredge boat for the United States Government. The boat is intended for use on the Cumberland and Tennessee rivers, and its first work will be on the Mussel Shoals Canal. The boat is 80 ft. long, 35 ft. beam, 6½ ft. deep. The dredge is of the elevator type, with steel buckets, and is so arranged as to discharge the material into the scows at either side, or over the end at any distance up to 80 ft. The same Company has recently furnished a large dredge to the New Orleans & Northeastern Railroad. It is to be used in filling up the long trestle over Lake Pontchartrain.

THE contract for the iron work of the new elevated line of the Philadelphia & Reading Railroad into Philadelphia has been awarded to A. & P. Roberts, of the Pencoyd Iron Works. It includes the iron work for the elevated line and for the train-shed and market-house at Twelfth and Arch Streets, and is one of the largest contracts in this line ever let.

THE Ship Owners' Dry Dock Company has recently completed a new timber dry-dock at Cleveland, O., which is 336 ft. long on the floors, 45 ft. wide at the bottom and 85 ft. at the top. The gate is 47 ft. wide on the sill, and has a depth of 15 ft. when the dock is full. The pumping machinery consists of two vertical pumps, each with 24-in. discharge, driven by two horizontal engines, with 18 × 20 in. cylinders. These pumps will empty the dock in 45 minutes.

THE *Marine Review* reports about 40,000 tons now under construction in the Lake ship-yards. This includes two wooden vessels and one steel one in the Wheeler Yard at West Bay City; a large wooden steamer in the Davidson Yard at West Bay City; two lumber-carrying boats at the Marine City Yard; a steel steamer in the Detroit Dry Dock Company's yard, and eight whalebacks in the yard of the American Steel Barge Company, at West Superior.

THE power station of the East End Electric Light Company, in Pittsburgh, is entirely supplied with the Westinghouse engine. The company has in its plant 15 of these engines, aggregating 1,800 H.P., and including two 18 and 30 × 16 in. compounds; three 11 and 19 × 11-in. compounds; one 18 × 16-in. standard; three 15½ × 14-in. standard; four 12 × 11 standard; one 11 × 10-in.; and one 7½ × 7-in. standard. There are 21 dynamos run by these engines, aggregating 12,000 incandescent and 420 arc lights.

THE New York Central & Hudson River Company has contracted with the Consolidated Car Heating Company, of Albany, N. Y., for the re-equipment of all its cars, the work to be completed within 60 days. The Consolidated direct steam system with the Sewall coupler will be used. The Consolidated Company has also recently received orders for 90 commingler equipments for the Canadian Pacific; 65 for the Boston & Maine; 50 for the Old Colony, and 35 for the Concord & Montreal. The Sewall coupler will be used in all of these.

THE Harlan & Hollingsworth Company, in Wilmington, Del., has lately taken contracts for four steel boats for service on Long Island Sound. These boats are a departure from the side-wheel type in general use on those waters, all having twin screws. Two of them are for the Providence & Stonington Steamship Company; they will be 310 ft. long over all, 302 ft. on the water-line, 44 ft. beam and 60 ft. over the guards. Each will have one triple-expansion engine, with high-pressure cylinder 28 in., intermediate 45 in., and two low-pressure cylinders, each 51 in. in diameter, all being 42 in. stroke. The other two boats, for the New Haven Steamboat Company, will be 315 ft. long over all, 300 ft. on the water-line, 47 ft. 10 in. beam and 53 ft. over the guards. Each will have two triple-expansion engines, with cylinders 24 in., 38 in. and 60 in. in diameter and 30-in. stroke.

THE firm of Watson & Stillman, of New York, have recently added 5,000 ft. to their already large hydraulic machinery works, greatly facilitating the production of railroad tools. The output of hydraulic jacks and car-wheel presses during the last two years has increased to such an extent that the adoption of this course was necessary in order to keep abreast with their orders.

THERE was a slight fire at the Richmond Locomotive Works, Richmond, Va., on the night of October 15, which was fortunately soon discovered, and was quickly extinguished by prompt action. Practically the only damage done was to the roof of the foundry, and full operations were only delayed for a day or two. These works are in a better condition for prompt and satisfactory work than ever before.

THE Riehle Brothers Testing Machine Company, in Philadelphia, has just completed a large vertical screw-power testing machine for the School of Practical Science in Toronto, Ont. This machine is arranged with two movable cross-heads for quick adjustment, for testing long and short specimens for tensile strength. It will test by tensile strains specimens from 10 ft. down to 6 in. long; transverse specimens from 18 ft. to 1 ft.; compression specimens from 12 ft. down.

ON October 1 there was cast at Carnegie, Phipps & Company's Homestead Steel Works a nickel-steel ingot weighing 25 tons, which was without a flaw. It is to be reheated and rolled into a single plate for the United States coast defense vessel *Monterey*, in course of completion. This was the largest nickel-steel ingot yet made in this country, but a few days later the works cast one weighing 50 tons, designed for the same vessel; when finished it will be 13 in. thick.

THE limited trains of the Erlanger system, which run between Cincinnati & Florida, have coaches elegantly furnished and supplied with all modern conveniences, including steam heat and Pintsch gas.

THE equipment of 200 cars for the New York, New Haven & Hartford Railroad with steam heat has been completed by the Safety Car Heating & Lighting Company, of New York. The New York & New England cars are being rapidly fitted with the Gibbs couplers, which are used in connection with the Safety Company's hot water circulating system.

Baltimore Notes.

WORK upon the tunnel of the Belt Railroad is progressing better than is generally known. Up to this date over 2,000 ft. of the brick work of the total 6,000 ft. have been completed and arched out.

THE directors of the City Passenger Railway Company—which includes the Red, White and Blue Lines—have selected sites for the three power houses of the new cable line, and the board has confirmed the purchase. One house will be located

on South Eutaw Street, between German and Lombard ; one at the corner of East Baltimore and Easts street, and one at or near the terminus on West Baltimore Street, above Fulton Avenue.

THE Baltimore & Ohio is building a line that, when completed, will be known as the Metropolitan Southern, and will run from Linden on the Metropolitan Branch, nine miles west of Washington, to a point south 24 miles. It will be a single track road. Mr. W. L. Sission, Assistant Chief Engineer, has charge of the construction.

IT is rumored that after January 1, 1892, the Monongahela River Railroad in West Virginia will be operated by the Baltimore & Ohio Railroad as part of its Wheeling & Parkersburg Division.

THE Mt. Clare shops, Baltimore & Ohio Railroad, have received orders for the construction of seven new 52-ft. baggage cars, 15 new standard caboose cars, and two standard derrick cars.

THE Baltimore & Ohio has about completed at Benwood and Wheeling, W. Va., improvements which will vastly facilitate the transaction of business at those important points. At Benwood a large yard, with 10 miles of track, has been finished, and here the freight business coming west of the Ohio River, as well as that going west from the Main Line and Pittsburgh Division, and Baltimore, will be classified and distributed. The Company is also about to build a commodious passenger station at Benwood, with eating-house and a large round house, with immense shops. The shops now at Wheeling and Bellaire will be removed to Benwood. There has also been constructed at Benwood a connection between the main line and the approach to the Bellaire Bridge, which will enable all trains to pass over without reversing engines or cars.

THE South Baltimore Car Works, Curtis Bay, have arranged to overhaul and paint 250 Wickes Refrigerator Cars for the Baltimore & Ohio Railroad.

Emery Wheels.

A REPORT has recently been made public of a series of tests of solid emery wheels, made by Messrs. Coleman Sellers, J. E. Denton and Alfred R. Wolff. From this report we take the following extract:

"It was unanimously agreed that hand testing must be done away with and the personal factor eliminated, in order that the results might be unimpeachable. The defect of existing test machines was speedily recognized, and it became necessary to invent a new testing machine. After much study and many trials your Board, with the valuable assistance of Professor Webb, of Stevens Institute of Technology, at Hoboken, constructed a machine which met the approval of all concerned.

"It was agreed, that to constitute a good solid emery wheel, the following qualities should be combined: safety under the widest conditions of use and misuse; rapidity of cut; freedom of cut at moderate pressure; reasonable amounts of wheel loss and power consumption; evenness of wear; general staying quality; and reliability under the widest range of circumstances.

"Our Board then agreed upon a programme of work—had the test machine erected in the machine shop of the Stevens Institute of Technology, at Hoboken—and had the various wheels (bought directly by themselves) delivered at Stevens Institute. The grinding was done on cast-iron bars supplied directly to us by one founder, special care being taken as to quality of metal and size of bar. The trials reported on were made at the Stevens Institute during 1889 and 1890, the tabulations being too voluminous to admit of detail here. During the latter part of this investigation the assistance of Professor Jacobus (Assistant Professor of Experimental Mechanics at Stevens Institute) was secured.

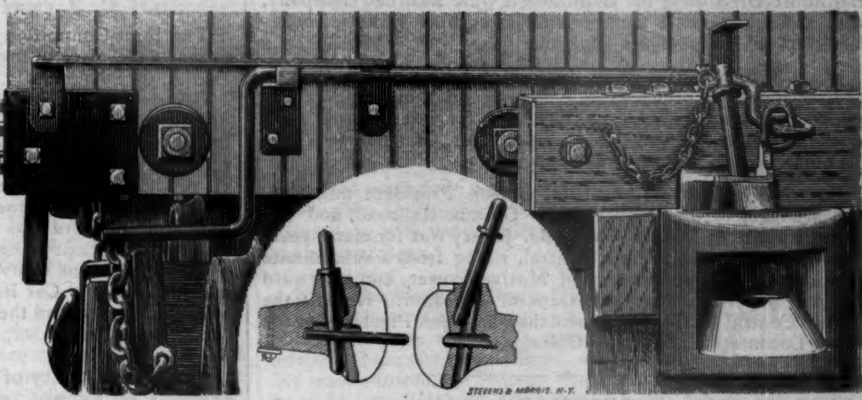
"In preliminary and collateral investigation many trials were made with hand pressure, and some under measured pressures of 10 lbs. and 75 lbs.; but our report is based on a long series of trials at three different pressures—42 lbs., 60 lbs. and 100 lbs. These separate trials numbered several thousand, during each of which exact data were recorded as to speed, power, resistance between wheel and metal, amount of metal ground off, amount of wheel material consumed, and observations made as to the cleanness of cut, amount of heat generated, amount of blazing or clogging up of wheel with metal, and as to cracks, breaks and defects of wheels.

"Of the 15 varieties, six were found too unsafe to warrant their general use, 57 per cent. of the wheels bursting under the same conditions which other wheels passed through uninjured. Eleven varieties (among which are included the six unsafe varieties) were found to be such slow cutters that the average metal removal of 10 of them was less than the general average of all the wheels. Of the 15 varieties only four were found to be rapid cutters. Of these one wore so rapidly that the cost of its rapid cut was unreasonable. This left three safe, effective and satisfactory wheels, one of which, however, was demonstrated to work at a greater cost than the Tanite. The rivalry was thus narrowed to two wheels, and, in the judgment of our Board, further trials are necessary before the relative value of these two can be determined.

"One striking feature characterized these two. That is, that in every series of trials these wheels increased in productive capacity, the average of the last cuts of all the series being greater than the average of all the first cuts. The 13 other varieties all decreased in productive capacity, the average of the last cuts being less than the average of the first. Some of these which made a brilliant show at the start cut scarcely anything at the close."

The McEntee Coupler.

THE illustration herewith shows the McEntee coupler as



applied to cars on the Northern Pacific Railroad. The inventor states that it has worked well on that road and has given satisfaction, as it couples without difficulty with the common drawbar. The cut shows the manner in which it is arranged on the car, the smaller view (enclosed in a semicircle near the center) showing a section of the draw-heads. In the engraving the pin is in position just ready to couple.

Experience with Steel Ties.

IN October, 1889, some steel ties of the pattern made by the Standard Metal Tie & Construction Company were laid in the track of the Chicago & Western Indiana Railroad. The following is an extract from a report made on these ties after two years' use, by Mr. John W. Clarke, formerly Roadmaster of the road:

"I find the total expense on the stretch of 1,000 ft. of steel ties during the 19 months they were in, while I was connected with the road, was $45.50, and the greatest portion of this was caused by the first surfacing-done, after track had been laid in the soft ballast, to bring them up to the same elevation as the track on wooden ties alongside. During the same time the cost for labor alone for the 1,000 ft. of track with wooden ties alongside of the steel ties was $210.25, showing enough saved on labor alone to purchase 65 new steel ties.

"The life of the rails, by reason of their being held rigidly upright, must certainly be increased by a good many per cent., and this should go to the credit of the ties. My observation of the lessening of oscillation and vibration on engines and cars, especially on heavily loaded cars of yielding material like grain, leads me to believe that engines and cars running on a road laid with such ties would show a saving in repairs and a longer life. It is also certain that spreading of the rails cannot occur, and that, if a rail breaks, the chances of an accident occurring from that source are reduced to a minimum."

Sections of track have recently been laid with these ties on the Long Island Railroad, near the terminus in Long Island City, and on the Philadelphia & Reading in Philadelphia. In both places they will be subjected to a very severe test.

PERSONALS.

W. T. JENNINGS has resigned his position as City Engineer of Toronto, Ont., and will re-enter railroad work.

RICHARD H. TALCOTT has resigned his position as Chief Engineer of the Seattle & Eastern Construction Company, and will return to the East.

JOHN C. WILLIS, of Metropolis, Ill., has been appointed a member of the Illinois Railroad Commission in place of JOHN R. TANNER, who has resigned.

H. B. LA RUE, who is well and widely known wherever railroad supplies are bought, is now open to an engagement, having resigned his last position.

GEORGE RICHARDS has been appointed Master Mechanic of the Elmira, Cortland & Northern Railroad, with office at Cortland, N. Y., succeeding THOMAS KEARSLEY, who has resigned.

J. F. O'ROURKE, recently Engineer for the contractors of the Chignecto Ship Railroad, has been appointed Engineer in Charge of Surveys for the Rapid Transit Commission, New York.

H. B. PRINDLE, formerly with the Thomson-Houston Electric Company, has opened an office at 53 State Street in Boston, as an advertising agent for manufacturers, and also for the preparation of catalogues and price-lists.

JOHN E. SPURRIER has been appointed Train-Master of the Baltimore Division of the Baltimore & Ohio Railroad Company, with headquarters at Cumberland, *vice* JOHN BARRON, transferred to the Philadelphia Division.

W. D. CROSMAN, for some time past Editor of the *Railway Master Mechanic*, of Chicago, has resigned that position, and has been appointed Associate Editor of the Consolidated *Railway Age* and *Northwestern Railroader*. Mr. Crosman will have his office for the present in Minneapolis.

EDWARD T. JEFFERY has been chosen President and General Manager of the Denver & Rio Grande Railroad, and will have his office in Denver, Col. Mr. Jeffery was for many years connected with the Illinois Central, rising from a subordinate position to be Superintendent of Motive Power, and afterward General Superintendent and General Manager. He left the Illinois Central in 1889, and since then has been President of the Grant Locomotive Works, of Chicago.

OBITUARY.

CHIEF ENGINEER JAMES BUTTERWORTH, U. S. N., died in North Cambridge, Mass., October 6. He entered the Navy in 1861 and rose gradually until he was appointed Chief Engineer in 1881. He was a constant student and was considered an authority on modern machinery, and especially on applications of electricity.

ARCHIBALD R. TAYLOR, who died at his home at Pine Bush, N. Y., September 28, aged 84 years, was for many years a civil engineer. He was employed on the original surveys of the Erie Railroad, and was one of the party which began the first railroad survey in Chicago. He retired from active work some years ago.

JOHN BAIRD, who died in New York, October 17, aged 71 years, was of Scotch birth, but passed nearly all his life in America. For a number of years he was connected with the Burden Iron Works in Troy, N. Y., and about 1854 he removed to New York City, where he was connected with the Delamater Iron Works. In 1859 he was appointed Chief Engineer of the Cromwell Steamship Line, and nearly all the boats of that line were designed by him. When the Metropolitan Elevated Railroad Company was organized, Mr. Baird was made Vice-President and Manager; he superintended the building of the road and retained his position up to the time of the consolidation by which the present Manhattan Company was formed.

FREDERICK JARVIS SLADE, who died October 11, aged 49 years, was born in Boston, but removed to New York at an early age, graduated at the City College, and was for a time in the Morgan Iron Works. Subsequently he studied in Europe, and was for some time associated with the late Alexander L. Holley. Nearly 25 years ago he entered the employ of the New Jersey Steel & Iron Company at Trenton, and in 1868 built for that Company the first open-hearth steel furnace in this country. After acting as Engineer of the Company for some years, Mr. Slade was appointed General Manager, and held that position until his death. He was considered a high authority on metallurgical questions, and wrote a number of valuable reports and papers.

JOEL BENEDICT HARRIS, who died in Rutland, Vt., October 19, aged 69 years, was born in Sterling, Conn., and graduated from the Rensselaer Polytechnic Institute at Troy, as a civil engineer, in 1840. After working at his profession for some years he became a contractor, and did some heavy work on the Harlem, the Boston & Albany, the New York & New Haven and other roads. In 1860 he settled in Rutland, and there established the Rutland Foundry Company, manufacturer of car wheels and other castings. This concern was reorganized in 1882 as the Harris Manufacturing Company, and Mr. Harris remained President until his death; he was also President of the Springfield Foundry Company at Springfield, Mass. He leaves a widow and six children.

PROCEEDINGS OF SOCIETIES.

Master Car Builders' Association and American Railway Master Mechanics' Association.—The following circular has been issued by the Joint Committee of Arrangements, consisting of Messrs. R. C. Blackall, J. W. Marden, E. Chamberlain, O. Stewart and Angus Sinclair:

NEXT CONVENTIONS.

The Joint Committee of the above Associations, empowered to select the place of meeting for the next Conventions, met at Buffalo on September 7, and decided on Saratoga, N. Y.

Congress Hall Hotel has been selected as the headquarters of both Associations. The members and all others attending the Conventions will receive accommodation at the uniform rate of $3 per day. Application for rooms should be made to H. S. Clements, Congress Hall, Saratoga, N. Y.

As the second Wednesday of June happens on the 8th next year, and as there was difficulty in getting a hotel to open so early, the Executive Committees of the two Associations decided to postpone the Conventions one week. Under this arrangement the Master Car Builders' Convention will meet on Wednesday, June 15, and the Master Mechanics' Convention on the Monday following.

American Society of Mechanical Engineers.—The twelfth annual meeting will be held at the Society's house, No. 12 West Thirty-first Street, New York, beginning Monday evening, November 16. At this meeting the usual routine business will be transacted, officers for the ensuing year elected, and there will be several sessions for the reading of papers and discussions.

Secretary F. R. Hutton has issued a circular stating that a proposition has been made to hold the spring meeting of 1892 in California. The question has come before the Council, and it has been decided to accept invitations from the Pacific Coast, provided the members at large approve of the selection. The cost for the journey will not exceed $300 each, including visits to prominent points of interest, and may be reduced if a sufficient number of members accept.

American Railway Association.—The fall meeting of this Association—formerly called the General Time Convention—was held in New York, October 14. The President, Colonel H S. Haines, made an interesting address on the Cost of Transportation, noting the elements which should enter into it and the manner in which it should be estimated.

Mr. Willard A. Smith, Director of Transportation Exhibits of the Columbian Exposition, addressed the meeting on the plans made for this work, and the prospects for carrying it out. Resolutions were passed in favor of this work. Resolutions were also passed expressing interest in the timber tests now being made by the Department of Agriculture.

The Car Service Committee made a report, saying that the system of Car Service and Demurrage Associations, so far as carried out, was working very successfully.

The Committee on Safety Appliances reported progress, and submitted a resolution, which was adopted, to the effect that continuous steam heating should be the standard system of the Association, and that lighting with high-test oil is practically safe.

The Committee on Train Rules reported that the standard code is now in use on 109 roads, operating 76,000 miles, and that 17 more roads with 7,000 miles were soon to adopt it. The Committee recommended no change in rules.

A delegation from the Train Dispatchers' Association presented some suggestion concerning new rules, which were received, acknowledged, and referred to the Committee on Train Rules.

American Society of Railroad Superintendents.—At the fall meeting in New York, October 12, several amendments to the constitution were adopted. The report showed that there were now 198 members.

The Committee on Transportation reported on some questions in train dispatching, stating that the questions were very complicated, and that they had not been able to recommend a final answer.

The Committee on Roadway made a report, discussing tie-plates and some patent spikes, and holding that 80 lbs. per yard was about the heaviest rail section to be recommended. If additional support was needed, it would be better to increase the number of ties. This report was discussed at some length.

The Committee on Machinery made a report on Car Heating, and on the Use of Malleable Iron in Car Construction; they stated that a regulator for controlling the degree of heat in cars was much needed.

Mr. W. G. Wattson read an interesting paper on Economy in Train Service, which was discussed at some length. At the close of this discussion it was resolved that the Committee on Transportation be instructed to prepare a catechism for the examination of trainmen.

A Committee of seven on Signaling was appointed to report at the next meeting. It consists of Messrs. J. J. Turner, James Donnelly, C. H. Platt, J. H. French, C. D. Hammond, W. G. Wattson, and O. E. McClellan.

Mr. Willard A. Smith was introduced, and made an address on the Transportation Exhibit at the Columbian Exhibition. At its close the Executive Committee was directed to take up the matter.

The following officers were elected: President, H. Stanley Goodwin; Vice-Presidents, C. W. Bradley, G. W. Beach; members of Executive Committee, R. G. Fleming, O. M. Shepard.

In the evening the meeting and the tenth anniversary of the Society were celebrated by a dinner at the Hotel Brunswick, at which about 40 members were present, and which was much enjoyed.

American Institute of Mining Engineers.—The fall meeting was held at Glen Summit, Pa., beginning October 6, and was largely attended. At the opening meeting addresses were made by Honorable Eckley D. Coxe, Chairman of the Local Committee, and by President Birkinbine, who referred to the work done by the Institute and the number of important papers brought out by it.

A number of important papers were read at this meeting. Among them were one by M. B. Holt, on Electricity in Mining; by H. O. Flipper, on Mining Surveys in Sonora; by W. H. Blauvelt, on Uses of Anthracite Waste; and by Albert L. Colby, on Nickel Steel. There were also discussions on Concentrating Iron Ores; Government Timber Tests; Tests of Iron and Steel and other subjects.

During the meeting the members visited a number of mines in the Lehigh Region.

American International Association of Railroad Superintendents of Bridges & Buildings.—This Association was organized at a meeting held in St. Louis, September 25, at which 60 persons were present or represented. After a temporary organization a Committee on Constitution and By-Laws was adopted, and presented reports, which were accepted. The following gentlemen were elected officers: President, O. J. Travis; Vice-Presidents, H. M. Hall, J. B. Mitchell, James Stannard and G. W. Hinman; Secretary, C. W. Gooch; Treasurer, George M. Reid; Executive Committee, N. A. MacGonagle, W. R. Damon, G. W. Markley, G. W. McGehee, J. E. Wallace, and G. W. Turner.

After some general discussion, it was decided to hold the next annual meeting in Cincinnati, on the third Tuesday in October, 1892. The following subjects were selected for report and discussion: 1. Surface Cattle Guards. 2. Frame and Pile Trestles. 3. Protection of Wooden Bridges against Fire and Decay. 4. Iron and Vitrified Pipe for Culverts. 5. Water Tanks and Accessories. 6. Interlocking Signals. 7. Station Platforms. 8. Paints for Iron Structures.

A committee of three members was appointed upon each of these subjects, to report next year.

American Association of Railroad Clerks.—This Association, which was organized at Cleveland, O., last year, held its second convention in St. Louis, September 16–18. At the opening session addresses of welcome were made; and President J. H. Hanna delivered the annual address, in which he stated that there were now 16 local organizations attached to the Association, with nearly 1,100 members. The Secretary's report showed a prosperous condition.

On the second day a number of amendments to the constitution and by-laws were presented and referred, and the routine business was despatched. In the evening the visiting delegates enjoyed a banquet at the Lindell Hotel, given by the local association.

On the third day resolutions were adopted against strikes, and some changes in the constitution were approved. The following officers were elected for the ensuing year: Grand President, George A. Round, Boston; First Grand Vice-President, P. P. Walsh, Cairo, Ill.; Second Grand Vice-President, W. G. Staley, Troy, N. Y.; Grand Secretary, Frank L. Solomon, Boston; Grand Treasurer, W. C. Pearce, Cleveland, O.; Grand Door-keeper, J. R. Allen, Cincinnati, O; Executive Committee, W. F. Moore, W. J. Russell, R. M. Conlish, C. Manlove, N. M. Leach and George B. McGuire; Grand Trustees, E. H. Bassett, George H. Leonard and C. W. Eagan.

Philadelphia was selected as the place for holding the next yearly convention.

American Society of Civil Engineers.—At the regular meeting in New York, October 7, the following candidates were declared elected:

Members: Casper W. Haines, Guatemala; Charles F. B. Haskell, Wenatchee, Wash.: Alfred A. Stuart, Newport, Ky.

Associate Members: Frederick W. Abbott, Zumpango, Mexico; George E. Gifford, Cleveland, O.

A paper on Screw Steamship and Tow Barge Efficiency on the Lakes, by Joseph R. Oldham, was read. The second paper was by Captain O. M. Carter, U. S. Engineers, on Experiments with Dynamite on an Ocean Bar. This was discussed by Messrs. Collingwood, Brush, Reed, North and Bogart, who described work done on the bars in New York Harbor and elsewhere, Mr. Collingwood referring to some successful work now being done with the centrifugal pump in the removal and dredging of sand bars.

New England Railroad Club.—At the regular meeting in Boston, October 14, the subject for discussion was Lighting of Passenger Cars, which was opened by Mr. F. D. Adams, who advocated the use of oil lamps, especially the Sherburne lamp. He was followed by Messrs. Coghlan, Lauder, Dickson, Oldham, Butler, Richards, Chamberlain, and others, the merits of the Pintsch gas system and of the oil lamp being presented from different standpoints. It seemed to be generally agreed that electric lights for cars were still too expensive for general use.

New York Railroad Club.—The first meeting of the season was held at the Club rooms, in New York, September 17. No paper had been prepared for the meeting, but a discussion was had on the best method of Setting Tubes in Locomotive Boilers. This subject was discussed by Messrs. G. W. West, W. H. Lewis, Blackall, Kells and others. The general practice seemed to be the use of copper ferules either with or without swaging the tubes. A number of subjects were suggested for future meetings, and it was understood that besides formal papers, there would be a discussion on one topic at each meeting.

Engineers' Club of Philadelphia.—At the regular meeting, June 20, reports were presented upon the International Engineering Congress and the Incorporation of the Club.

Mr. Charles S. Churchill read a paper on Rail Joints, referring to the defects in existing joints, and describing a plan devised by himself for avoiding them. This paper was discussed by Mr. Trautwine and others.

The tellers reported that the following had been elected Active Members of the Club: Messrs. James McCann, S. W. Putnam, Neville B. Craig, D. W. Taylor, John Overn, Abraham Bruner, Charles L. Prince, John V. W. Reynders, Frederick Bloch, O. M. Weand, William J. Smith, Henry Howson, George McCall, George L. Van Zandt, W. W. Stevens, Clarence M. DuBois; and that Mr. Albert Priestman had been elected an Associate Member of the Club.

At the regular meeting, October 3, a paper was read by Mr. Trautwine, compiled from data furnished by Captain S. C. McCorkle upon Land-locked Navigation from New York to Charleston. A written discussion of this paper by J. Foster Crowell, of New York, was also read. The paper was verbally

discussed by members present. Some resolutions which were offered, constituting a memorial to Congress in favor of the scheme, were postponed until the next meeting.

A paper by Mr. Saunders Morris on the Electrical Transmission of Power was read, and also a letter from Mr. Coleman Sellers giving information with regard to the transmission of power from Lauffen to Frankfort.

Mr. B. H. Coffey read a paper on the Effect of Centrifugal Force on the Transmitting Power of Driving Ropes, giving formulas based upon experiment. These papers were briefly discussed.

Civil Engineers' Club of Cleveland.—A regular meeting was held on Tuesday evening, September 9, with President Gobeille in the chair and 18 members present. The Secretary being absent, Mr. C. M. Barber was chosen Secretary *pro tem.* Mr. Henry A. Barren and Perry L. Nobbs were elected active members.

It was voted to have a visiting day, when the members of the Club in a body will visit the different manufacturing establishments of Cleveland and engineering works in the vicinity, and a permanent committee was appointed to designate the days and arrange programmes.

President Gobeille then read an interesting paper on Straw and Corn on the Cob as Fuel for Domestic Purposes, in which it was stated that it had been found from experiments that the same quantity of heat could be generated by the combustion of straw or corn on the cob, pound for pound, as could be generated by the combustion of any other fuel. One of the principal difficulties in designing stoves for burning straw is to provide for the liquid products of combustion which are comparatively large in quantity. Several drawings of different stoves designed for burning straw were exhibited, also diagrams showing temperature curves obtained by platting colorimeter and pyrometer readings from experiments recently made. The difficulties of burning lignite, and the need of stoves for burning this material, which abound in many parts of the country destitute of true coals, was also discussed. The result of ten experiments were platted against lines derived from similar treatment of bituminous coal.

Engineering Association of the South.—The first fall meeting was held in Nashville, Tenn., October 9. The Nominating Committee submitted a list of names for officers to be balloted for at the annual meeting in November.

The following new members were elected: Frank Cowley, Benjamin W. Robinson, Earlington, Ky.; Thomas D. Kemp, Mobile, Ala.

Mr. W. H. Ross read a paper on Estimation and Measurement of Earthwork, comparing several methods now in use and showing their errors as compared with the prismoidal formula. One of the conclusions was that since earthwork excavations are usually bounded by a concave profile, the prismoidal formula gives results less than the actual volume taken out. The method of "averaging and areas" was considered the most correct. The author presented some tables devised by himself, and showed some graphical scales for the same purpose, and to be used in finding the center of a mass of excavation.

Southern & Southwestern Railroad Club.—At the regular meeting in Nashville, Tenn., September 24, there was a discussion on Breaking of Locomotive Side Rods. A letter from a superintendent of motive power was read, and diagrams of some curious breakages were shown.

Mr. Robert Walker read a paper on Draft Gear for Freight Cars, which was discussed at some length.

The election of officers for the ensuing year resulted as follows: President, R. D. Wade, Richmond & Danville; First Vice-President, Pulaski Leeds, Louisville & Nashville; Second Vice-President, James Meehan, Queen & Crescent; Treasurer, A. G. Steinbrenner, American Refrigerator Transit Company. The Secretary for the past year, Mr. W. H. Marshall, resigned, and it was decided that the selection of some one to fill the vacancy should be postponed until the November meeting.

Atlanta was chosen as the next place of meeting, the date being November 19.

The subjects for the next meeting are Uniformity in Reports of Locomotive Performance, and Repair Work on Large Roads; whether it can best be done by concentration in large shops or by distribution among smaller shops.

Western Railroad Club.—At the regular September meeting in Chicago, which was the first meeting of the season, the Secretary presented a report covering the last year's work of the Club. He said that there are now about 225 members, and that the publication of the Club *Proceedings* in pamphlet form had resulted very satisfactorily.

The following officers were elected for the ensuing year: President, P. H. Peck; Vice-Presidents, W. H. Lewis and Joseph Townsend; Secretary, W. D. Crosman; Treasurer, Allen Cooke.

At the regular meeting in Chicago, October 20, the first topic for discussion was Air-Brake Practice, continued from the September meeting. Brake experts and representatives of brake companies were invited to attend the meeting.

The second subject was Water Purification, on which a paper was read by J. N. Barr, of the Chicago, Milwaukee & St. Paul Road.

Northwestern Track & Bridge Association.—At the regular meeting in St. Paul, October 16, the report of the members who were present at the Convention of the Roadmasters' Association was presented, and some discussion was had on that subject.

A paper was presented by Mr. Rafferty on Proper Foundation for a Right-Angle Crossing, which was discussed by members present. There was also a discussion on Mr. Gonagle's paper on Preservation of Bridge Timber, which was read at the September meeting.

Northwest Railroad Club.—At the regular meeting in St. Paul, October 20, the first subject for discussion was Painting Rolling Stock, on which a paper was read by Mr. J. O. Pattee.

Mr. P. H. Conrad read a paper on Fuel and Economy in its Use. Both papers were generally discussed by members present.

Technical Society of the Pacific Coast.—At the regular meeting in San Francisco, October 2, six new members were elected.

Mr. T. W. Morgan read a paper on Sewer Systems and the Purification of Gases from Sewers. He also exhibited models of traps, showing charcoal in a channel through which noxious gases are made to pass. The paper and the systems recommended were discussed by the Society.

M. Manson's paper on the Cause of the Glacial Period, read at the preceding meeting, was also discussed.

NOTES AND NEWS.

Breaking of Locomotive Side Rods.—At a recent meeting of the Southern & Southwestern Railroad Club a letter was read from the Superintendent of Motive Power of a road which was not named, describing some breakages of locomotive parallel rods. The road in question uses solid-end rods of steel, with oil-cup forged on the end, of the pattern shown in fig. 1. The steel used is of good quality, as shown by the fact that

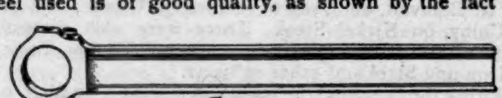


FIG. 1.

FIG. 2.

FIG. 3.

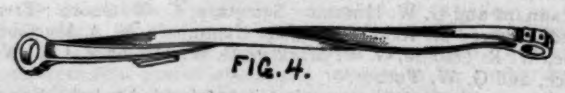


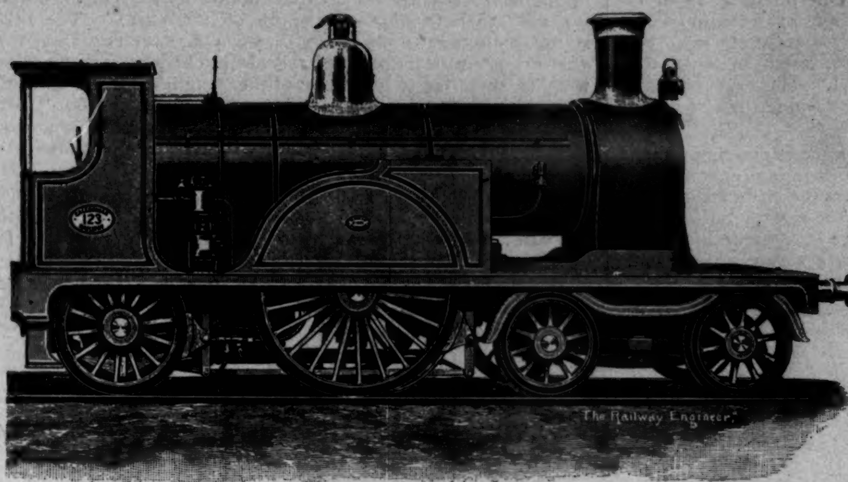
FIG. 4.

tests of specimens from broken rods showed an ultimate strength of from 70,700 to 73,100 lbs., with an elongation of 23 to 29 per cent.

Figs. 2 and 3 show different views of a rod which was broken in service, the cause being the breaking of the driving axle close to the hub of the wheel. The rod broke short off, but was twisted into a spiral before it broke.

Fig. 4 shows another rod which was twisted into the form illustrated, but did not break. Still another rod of the same kind broke while the engine was running, but no cause could be assigned, and tests showed the material to be fully equal to that of the others. Open-hearth steel is used for all these rods.

An English Express Locomotive.—The accompanying illustration, from the *Railway Engineer*, is a fair specimen of the express locomotive as built in England by those engineers who still adhere to the inside cylinders—which most of them



do—and to the single drivers—which many do not. This engine was built by Neilson & Company, Glasgow, Scotland, for the Caledonian Railway, and has run 100¾ miles in 102½ minutes with a train weighing—including engine and tender—168 tons.

The engine, as shown in the cut, has a four-wheeled truck forward, a single pair of drivers, and a pair of trailing wheels behind the fire-box. The total wheel-base is 21 ft. 1 in. The grate area is 17.25 sq. ft. and the total heating surface 1,053 sq. ft. The boiler is of iron, the fire-box of copper, and the tubes of brass. It is fitted with Adams' "vortex" blast-pipe.

The cylinders are 18 in. in diameter and 26 in. stroke; the driving-wheels are 7 ft. in diameter. The frames are of the plate type, of steel and the pedestal jaws of cast-iron, those for the driving axle being fitted with packing pieces to take up the wear of the axle-boxes. The axle-boxes are of gunmetal lined with white metal. The slide-bars and blocks are of cast iron, as are also the eccentric straps and sheaves.

The total weight of this engine in working order is 92,850 lbs., of which only 38,080 lbs. are carried by the drivers, 29,680 lbs. resting on the truck, and 25,090 lbs. on the trailing wheels.

A New Method of Cleaning Sewers.—In a recent number of the *Wochenschrift* of the Austrian Engineers' Union, Herr Emil Sokal describes a contrivance invented by him for the purpose of clearing the sludge in the Warsaw sewers, where the fall is too slight to admit of its being removed by the ordinary means of flushing. Recently some 25 miles of new drains have been laid in Warsaw, but out of about 900 houses in the neighborhood only 250 drain into them, the remainder being connected with the old drains of the city, which receive also the rubbish from the houses and the street sweepings, and occasionally are so blocked with deposit as to resist the ordinary flushing power, and manual labor has to be resorted to.

The fall of the new sewers is generally sufficient to keep the bottom clean by flushing only, but there are two or three places where the fall is less than 1 in 1,000, and therefore require special arrangements. Warsaw also had a network of old wood and brick drains nearly three parts full of mud and deposit, which led straight to the river Vistula by the shortest cut. The new main sewer runs parallel to that river, and is frequently crossed by these old drains. Connections with the new sewer were made at these crossing points, and this arrangement seriously affected the discharge of the new sewer.

At certain intervals, dependent on the fall, flushing-gates are built in the sewer, and on the whole this arrangement answers its purpose completely, but in some places, as before mentioned, deposits are met with which resist the flushing power and necessitate removal by hand.

With a view to do away with this manual labor, Herr Sokal, in 1889 (after an examination of the methods adopted under similar conditions in Munich, Zurich, Lausanne and Berlin), prepared the following simple contrivance. A wooden templet or mould fitted to the profile of the sewer, rests on a batten 1½ in. thick, which is pointed at the end for the purpose of penetrating and loosening the sludge. The flushing sluice above the portion of the sewer to be cleaned is closed, and water allowed to accumulate. About 6 or 10 ft. lower down the templet with pointed scraper is set up; the sluice is now opened and the scraper, which is under the control of a workman, moves on and clears the deposit. If this be very solid and hard, a small shutter in the templet is opened and water sufficient to thin it is admitted, or the scraper may be used more than once at the desired spot.

A German Tender Coupling.—The accompanying sketch shows a coupling between the locomotive and tender which has been adopted for the fast passenger engines of the Wurtemburg State Railroads. These locomotives are of a new design, and are compound engines of the Von Borries type. The illustrations, which are from the *Organ für die Fortschritte des Eisenbahnwesens*, show in fig. 1 a section, and in fig. 2 a plan.

The coupling is designed to give full play in all directions, at the same time making a close and secure connection. The link *D* is held by the two studs *E E*, which fit in the brackets *F F* bolted to the frame of the tender, as shown. The forward end of the link *D* is a slotted yoke, in which is placed the block *C*, which is held in place by the horizontal pin *B*. The coupling-pin *A* passes through the block *C* and the drawhead. This drawhead is of cast iron, strengthened by a wrought-iron plate riveted on the lower side; it is bolted to the heavy iron plate which connects the locomotive frames at the rear end.

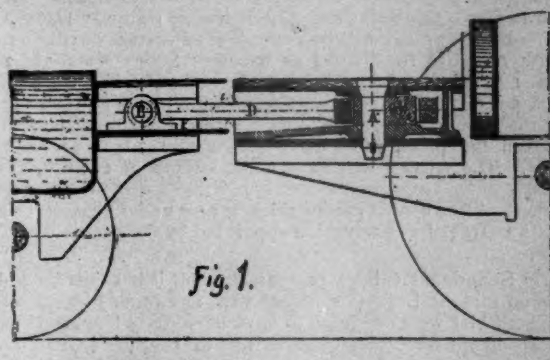


Fig. 1.

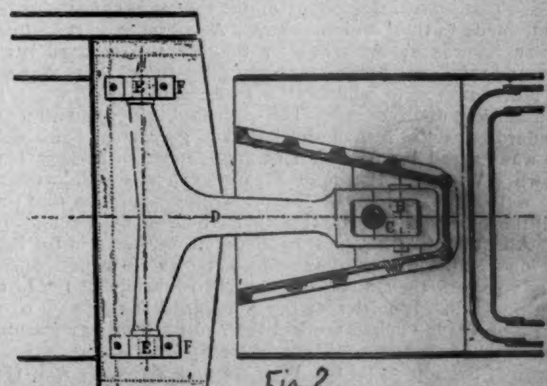


Fig. 2.

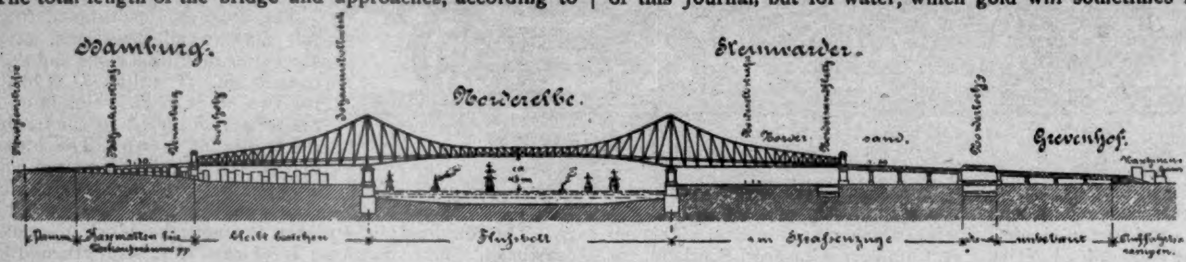
This coupling has been in use a year without perceptible wear. The coupling-pin *A* is 4.33 in. in diameter.

Color-Blindness.—A railroad engine-driver, 40 years of age, was dismissed from his situation because he was unable to correctly distinguish colors. Dr. M. Reich, who examined the man, and who afterward published the results of his examinations in a Russian paper, found sight, focus, and sensation of light normal, and discovered no disease by the ophthalmoscope, yet the patient could distinguish no colors when of a dark shade, and only yellow and blue when of a light shade. With the help of a red glass he could distinguish the figures on Tables II, III, VII, and VIII (Stilling). The patient assured Dr. Reich that he had been able to distinguish colors correctly and with confidence up to the summer of 1889. He said that through over-exertion and insufficiency of sleep he had then

suffered from violent headache for two weeks, and that afterward he saw everything as if it were red. The latter symptom had continued for three months, after which time he had lost all sensation of color. In the beginning of May, 1890, he presented himself again, declaring that he had perfectly regained his power to distinguish colors. A thorough examination completely confirmed the assurance given by the patient, who was consequently again fit for service. Dr. Reich believes that "erythropsy" is due to central mischief. The case seems to show that sensation of color is perfectly independent of the physiological function.—*London Lancet.*

A German High-Level Bridge.—The accompanying sketch, from the *Deutsche Bauzeitung*, shows a design prepared for a high-level bridge over the Elbe, to connect the city of Hamburg with the suburbs on the opposite side of the river. Such a connection is much needed, and surveys have been made for a tunnel under the river, but with very unsatisfactory results.

The total length of the bridge and approaches, according to the plan, will be 4,920 ft. On the Hamburg side the approach will be carried on stone arches; on the opposite side it will be a viaduct supported on stone piers. It is intended to carry a roadway, two sidewalks and double line of tramway tracks.



The bridge proper will be a cantilever structure having a total length of 2,952 ft., divided as follows: Shore arms, 787.2 ft. each, 1,574.4 ft.; river arms, 492 ft. each, 984 ft.; connecting span, 393.6 ft. The river span, consisting of the two river arms and the connecting span, will have a clear opening of 1,377.6 ft. between the piers, and a clear height of 147.6 ft. above high water. The trusses will have a total depth of 229.6 ft. at the piers.

The building of this great bridge is now under consideration; it is in charge of a commission appointed by the Senate of Hamburg.

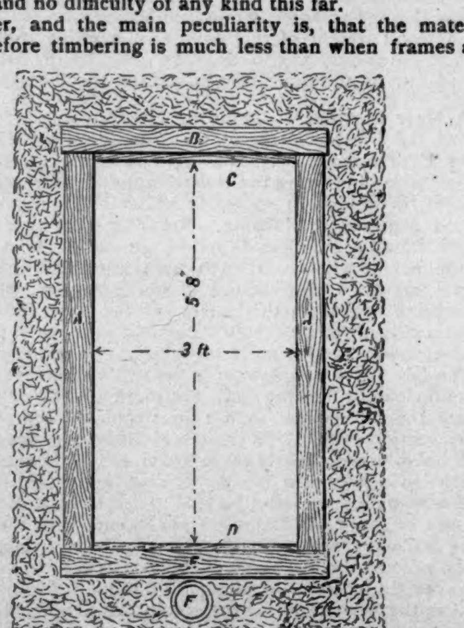
Old Standards.—By a curious accident it has just been discovered that the English standard yard and other measures and weights which were supposed to have been lost when the Houses of Parliament were destroyed by fire in 1834 are still in existence. The following account of the matter is condensed from a statement in the London *Times*. A reference to the contemporary records shows that after the fire the standard bars of 1758 and 1760 were both found among the ruins, "but they were too much injured to indicate the measure of a yard which had been marked upon them." The principal injury to both of the standards was the loss of the left-hand gold stud, but whether this was caused by the action of the flames or otherwise is not known. When the Palace of Westminster was rebuilt the two bars were deposited in the Journal Office, and from that time, until the other day, they seem to have been wholly lost sight of. About a fortnight ago it happened to be stated in the lobby that one of the duties of the Speaker was to inspect once in every 20 years the standards immured in the sill of the Lower Waiting Hall. Inquiries at the Standards Department of the Board of Trade elicited the fact that, so far from any statutory requirement being imposed upon the Speaker in the direction indicated, Section 35 of the Weights and Measures Act, 1878, which provides for the care and restoration of the Parliamentary copies of the Imperial standards, specially exempts the walled-up copy from periodical inspection and comparison. It was found, however, that in 1871 Speaker Denison took cognizance of the standards; and this fact was brought to the Speaker's notice. While inquiries were being made as to Speaker Denison's inspection, an official in the Journal Office mentioned that when the contents of that office were recently being transferred to the new wing he had observed among the lumber some old weights and measures. These proved to be the missing standards. On Tuesday last they were examined by Mr. Chaney, the Superintendent of Weights and Measures; and on Wednesday the Speaker was to visit the Journal Office for the purpose of inspecting them.

"The most important of the standards thus rescued from oblivion are the yard measures constructed by Bird in 1758 and 1760. The former was copied from a bar in the possession of the Royal Society, which was itself a copy of a standard preserved in the Tower; and the second was constructed under the directions of a Committee of the House of Commons from the 1758 standard. "Each of these two standard yards consisted of a solid brass bar 1.05 in. square in section and 39.73 in. long. Near each end of the upper surface gold pins or studs 0.1 in. in diameter were inserted, and points or dots were marked upon the gold to determine the length of the yard." The other standards in the custody of the Journal Office are two brass rods answering the description of the old Exchequer yard, and four weights supposed to be certain of the "copies, model, patterns, and multiples" ordered by the House on May 21, 1760, "to be locked up by the clerk and kept by him." The most important weight—the standard troy pound—is not among those now brought to light.

Tunnel Timbering.—From *Industry*, of San Francisco, which abounds in ideas, we take the following: "The Editor of *Industry* has had occasion to construct a tunnel. Not for gold, that being wholly unnecessary, because of emoluments of this Journal, but for water, which gold will sometimes not produce. This tunnel is timbered as in the diagram. Whether new or old is not known, but it certainly differs from common practice. The side timbers *A* are 3 × 12 in.; the cap *B* also 3 × 12 in. The foot timber *E* is 2 × 12 in., and the two strut pieces *C* and *D* are 1 × 12 in., all of redwood, cut to lengths at the mills and delivered ready for setting.

"The timbering consists, when complete, of a series of frames 12 in. deep, the top being 4 in. thick and the sides and bottom 3 in. thick. One peculiarity is that one of these frames is set as soon as the heading is advanced one foot. One man can set the timbers, which is performed as follows: A sewer, *F*, is first laid down, then the base piece *E* is set and leveled, the abutting piece *D* being first nailed on. Then the uprights or sides are set, and the cap *B* put in place. There has been no caving and no difficulty of any kind this far.

"Another, and the main peculiarity is, that the material removed before timbering is much less than when frames and



lagging are used—at least 25 per cent. less. Another point is that the tunnel is completely floored and dry, and water collected is preserved from fouling, or standing in contact with the timbers.

"The mouth of the tunnel was framed up like a house and a shed for tools made over it at the start, the cutting beginning through a door frame of the size noted on the sketch. The timbers are white-washed inside the tunnel wherever dry enough to admit of that; and as another departure the floor is swept out at intervals, and the whole carried on in a clean, orderly way. There is no loss, but, on the contrary, a gain by these methods over the usual slovenly way of working."